INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

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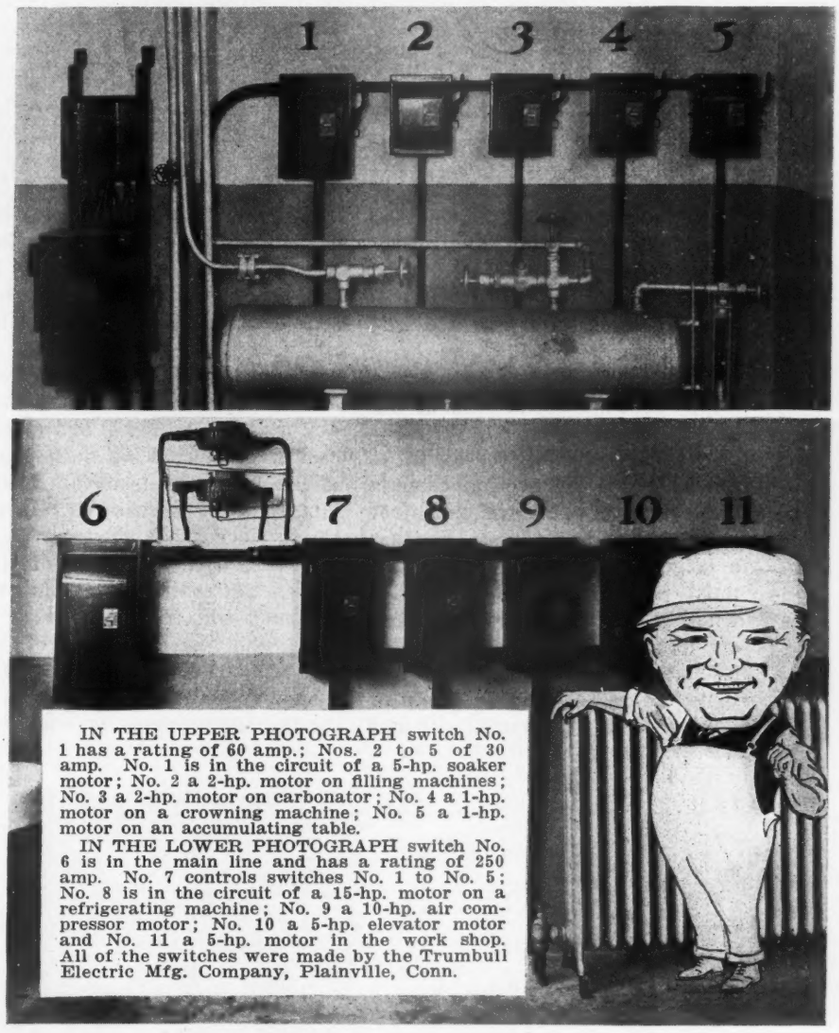
Two Good Clean-Cut Installations

That Show Work of the Head as well as the Hand From Operating and Safety Standpoints.



IN THE UPPER PHOTOGRAPH switch No. 1 has a rating of 60 amp.; Nos. 2 to 5 of 30 amp. No. 1 is in the circuit of a 5-hp. soaker motor; No. 2 a 2-hp. motor on filling machines; No. 3 a 2-hp. motor on carbonator; No. 4 a 1-hp. motor on a crowning machine; No. 5 a 1-hp. motor on an accumulating table.

IN THE LOWER PHOTOGRAPH switch No. 6 is in the main line and has a rating of 250 amp. No. 7 controls switches No. 1 to No. 5; No. 8 is in the circuit of a 15-hp. motor on a refrigerating machine; No. 9 a 10-hp. air compressor motor; No. 10 a 5-hp. elevator motor and No. 11 a 5-hp. motor in the work shop. All of the switches were made by the Trumbull Electric Mfg. Company, Plainville, Conn.

WHILE looking through the pages of a manufacturer's house organ that I regularly read because of its homely philosophy and down-to-earth discussions on business and things in general, I spied two photographs that showed work of the head as well as the hand. Two things got my interest: First the general character of the installation and second, the fact that I had been in the plant and had either missed something or these installations had been made since the time I was there. So I wrote to my good friend of the Coca Cola Bottling Company of Greenville, S. C., and asked him a few questions about these two installations and the photographs I had seen. He came back with a nice letter and sent the two photographs that are shown here.

In the caption under the pictures as they appeared in the house organ was this statement: "Greenville installations are safe under the guardianship of Mr. J. J. McDevitt, Electrical Inspector." Naturally, I was interested to know why Greenville installations are any safer under Mr. McDevitt's guardianship than others elsewhere under the guardianship of other men good and true—and I found out through the P. S. my good friend added to his letter which read as follows: "We had two reasons for this installation. First, we wanted the best, and second, our city laws require safety switches and all wires run in conduit." And then I got the point of Mr. McDevitt's guardianship but it seems to me that this is a left-handed compliment to Mr. McDevitt for under conditions where the plant operator wants the best and gets it, the work of the electrical inspector is not so much that of a guardian as it is of an endorser of things as they should be without the trouble of exercising his authority to force that situation.

There was a time when rules of National Electrical Code and municipal ordinances based upon it were sometimes wilfully evaded but these instances and the heated arguments which they called forth are comparatively rare now, mainly because standards of construction in industrial plants have greatly improved and the men in these plants realize that a good installation that will pass all inspections from the standpoints of service requirements, safety to workmen and fire hazards are the cheapest installations in the long run. We should, therefore, congratulate the men in the plants for this kind of thinking when it is displayed in their work rather than call attention to the fact that they are getting by the inspector who looks the job over mainly from its proof against fire hazards, on which an insurance policy covering the plant is written, or to see that it follows the letter of a city ordinance that deals with every installation as though they were exactly alike with little or no regard for the service requirements of different jobs.

Unless we are willing to give credit where credit is due we often find ourselves in the position of Abe Potash of Potash and Perlmutter combination when he said, "Work all your life to get somewhere and when you get there—where are you?"

The installations shown here any one might be proud of and I want to congratulate everyone who had anything to do with them.

Practical Pete

A Glimpse Into the

Works of Pillsbury Flour Mills Company

An organization which has taken an important part in the development of the greatest flour milling center in the world. This is the third of a series devoted to the growth and extent of basic American industries.

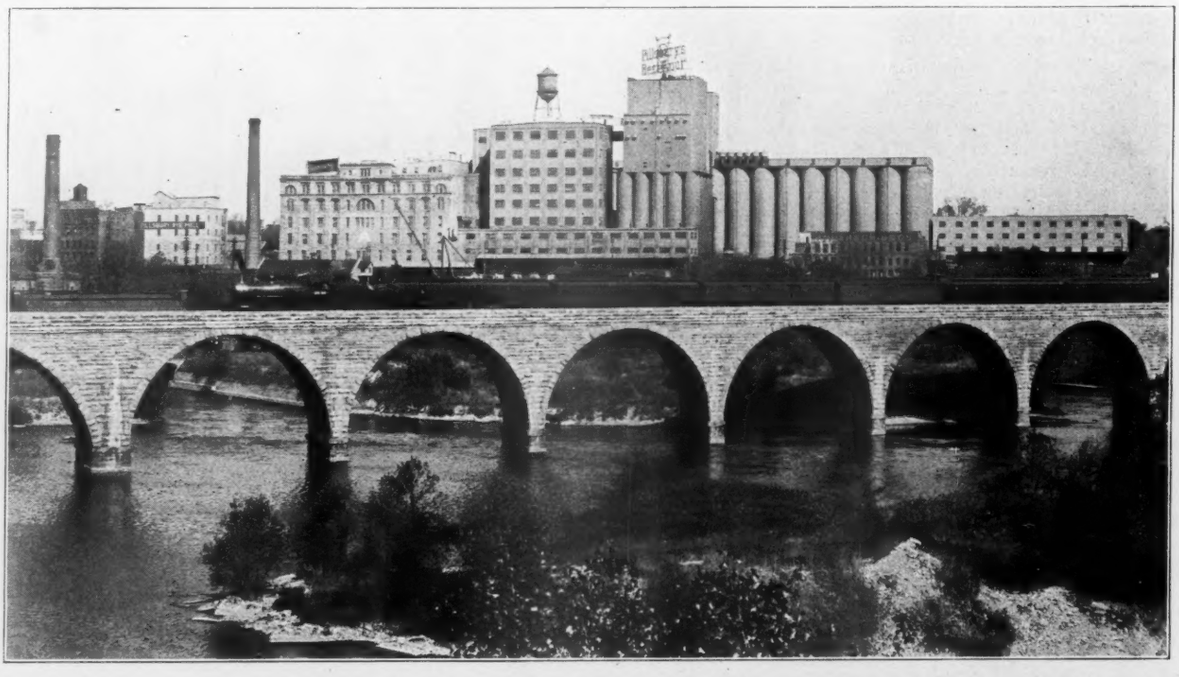
SEVERAL flour mills grouped around St. Anthony Falls at Minneapolis, Minn., are capable of producing 90,000 bbl. of flour per day. Of these the largest is the Pillsbury "A" mill with a daily capacity of 17,500 bbl. This concentration of an industry is largely due to location, water power, transportation and other economic reasons. Buffalo, N. Y., the second largest flour milling city, also owes its growth to similar reasons.

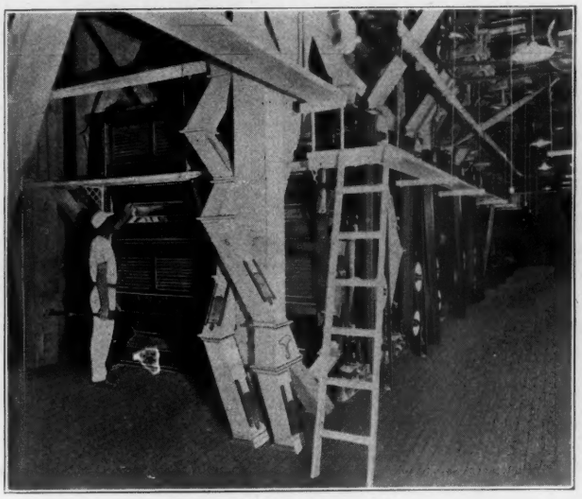
From the earliest period of history, wheat has formed one of the basic foods of the world. With the development of the Northwest as a wheat-growing section came a concentration and development of large milling centers. Because a large proportion of this wheat must pass through Minneapolis, where St. Anthony Falls offered opportunities for the utilization of water power, there was established there the largest group of flour mills in the world, of which the Pillsbury group is an important part.

The advantages of this location were recognized early, as records show the first mill was erected here in 1822 by the Federal Government. The first commercial mill was built in 1854. By 1866 eight mills were operating at the Falls with a yearly production of 172,000 bbl. of flour. In that same year the first of what later became one of the Pillsbury group of mills was erected. It was about this time that the advantage of the invention of the McCormick reaper and self-binder, as described on these pages in the February issue of INDUSTRIAL ENGINEER, was felt. In addition, increased transportation facilities, the entrance of the United States into the commerce of the world as an exporter of flour, and the invention of the middlings purifier, as well as the change from millstones to rolls in the milling process, have all contributed to making Minneapolis milling history. The growth was rapid; in 1876 the Minneapolis mills produced 1,000,000 bbl. of flour and had doubled this pro-

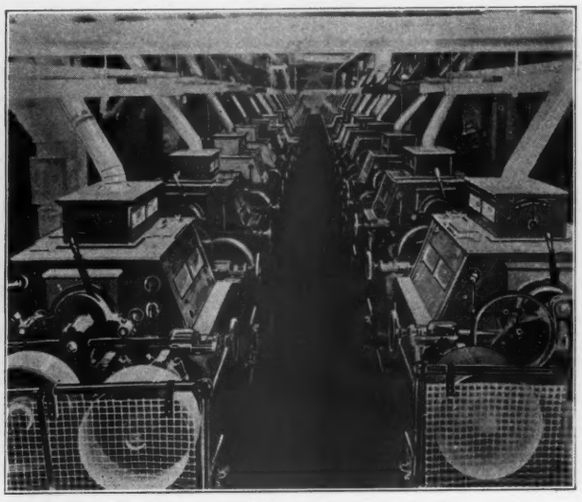
This largest flour mill in the world, with its daily capacity of 17,500 bbl., only equals the demand of New York and Philadelphia.

This largest unit of the Pillsbury group of mills in Minneapolis began in 1881 with the construction of the unit marked here with "A" with a capacity of 5,000 bbl. per day. The large circular tanks at the right are tile elevators with a storage capacity of 4,750,000 bu. A problem of the industry is that wheat is harvested and a large percentage of it marketed within a period of a few months; in contrast, the milling process is continuous. This mill is operated by a 2,000-hp. water turbine but has an auxiliary steam plant to maintain production in times of a water shortage. Some idea of the amount of work involved in the manufacture of flour may be gained from the fact that 19 reductions or grindings are accomplished in the breakers and rolls all located on the first floor and 180 separations, which separate the stock into middlings, bran, flour and screenings, take place on the fourth, fifth and sixth floors. The third floor is devoted to packing.





Attaching a new silk bolting cloth in the revolving cylinder of a reel. These machines operate with a shaking motion and separate the stock into middlings, bran, flour and screenings.

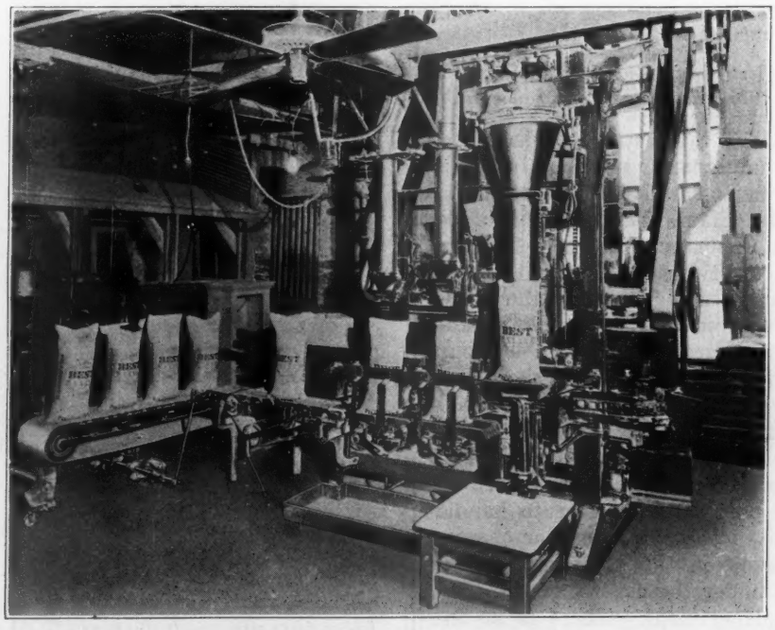


One of several rows of grinding machines in the Pillsbury "A" mill. There are 250 of these on one floor.

duction in 1880. By 1920 the total output of the Minneapolis mills was 16,883,000 bbl. of flour. It requires approximately 5 bu. of wheat to produce a barrel of flour which will make from 240 to 300 pound-loaves of bread. Government records show an average consumption of about 5 bu. of wheat per capita in the United States.

A part of the development of Minneapolis as a flour milling industry was the erection of what is known as the Pillsbury "A" mill in 1881, which was originally built with a daily capacity of 5,000 bbl. This building, identified here with the letter "A" on the front, is still a part of the Pillsbury "A" mill, the largest individual mill in the world with a daily capacity of 17,500 bbl. of flour, or 87,500 bu. of wheat. Large as this is, it is barely equal to the requirements of the cities of Greater New York and Philadelphia in their daily flour ration.

This mill is operated by a 2,000-hp. water turbine getting its supply from St. Anthony Falls. This turbine is placed about 50 ft. below the basement of the mill and is connected to the main line shafts by an endless hemp rope about 7,000 ft. in length. Belts, in turn, distribute the power to the various mills through the building. Because it is desirable to place the heaviest milling machinery on the first floor where it is near the line-shaft, the milling process begins on the first floor and the milled wheat progresses upward as it is operated on. It is a common practice in many other industrial processes to begin at the top of the building and allow the material to flow down by gravity as it is operated on. A particular feature is the large number of operations involved in the manufacture of flour. Aside from the cleaning, screening and washing of the wheat, which are done before reaching the mills, the wheat passes through 19 reductions or grindings in the breakers and rolls and 180 separations to remove the bran coat to produce white flour. It requires about an hour for the wheat to complete the manufacturing processes.



A giant flour packing machine which automatically fills, weighs and sews the sacks of "Pillsbury's Best." Four 49-lb. sacks make a barrel of flour.

The bench at the right is used for light work and is equipped with vises and an electric drill. At the left is the bench for armature winding and heavy work.

Some Practical Details of a Large

Industrial Plant Repair Shop

Together With the Methods of Handling Inspection and Repair Work in the Various Departments

By E. J. FORD

Chief Electrician, Kewanee Plant, Walworth Manufacturing Co., Kewanee, Ill.

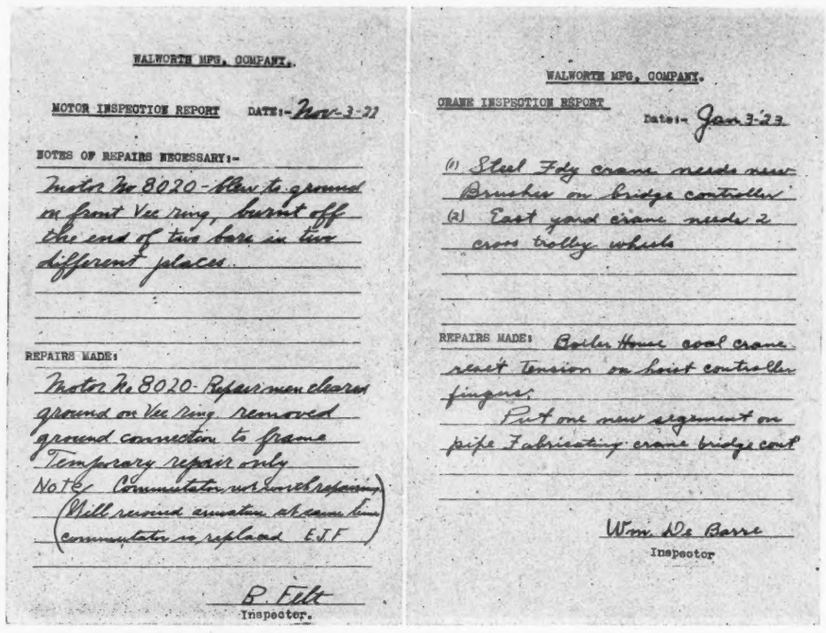
PRESENT methods of handling maintenance and repair work on electrical equipment in the Kewanee Plant, Walworth Manufacturing Company, Kewanee, Ill., are based on twenty years of experience and study in solving the problems involved therein and determining the procedure best suited to our conditions. The repair shop has lately been moved into larger quarters and new equipment installed; so that, with certain recent changes in the routine, we feel that we are in better position than ever to handle the job of keeping in proper operating condition the equipment which comes under the control of the electrical department. There is no intention to imply that our routine and methods cannot be improved, but experience has shown that under present conditions they accomplish their purpose satisfactorily.

A SYSTEMATIC schedule of inspection to detect motor and control trouble as soon as it develops and a well-equipped repair shop for handling the unavoidable breakdowns, mean low operating costs and minimum loss of production through failure of power service. In this article details are given of the methods employed and the facilities available for the maintenance of electrical equipment in the 29 departments, representing over 18 acres of floor space, in a plant which covers 36 acres of ground. Although 90 of 238 motors are exposed to dust and steam and acid fumes the care which they receive is so effective that not more than 15 motors are rewound a year.

The product of this plant is principally fittings, valves, pipe bends and drivewell points. For producing these articles there are in operation four foundries, steel, malleable and grey iron, and brass, a hot galvanizing plant, several machine shops, pattern shop, core rooms, and so on, involving twenty-nine departments in a plant covering thirty-six acres. All of the machines in these departments are motor driven, either individually or in groups. There are now installed 238 motors, with a total connected load of 3700 hp. Of these motors 219 are direct-current machines operating at 240 volts and representing 2700 hp. while there are 19 three-phase, 440-volt, 25-cycle squirrel cage induction motors carrying a load of approximately 1000 hp., one-third of the total power load

Motor and crane inspectors' report sheets.

All motors and cranes are inspected daily, but a written report is not required unless trouble is found. In this event the inspector describes the nature of the repairs needed and gives the report to the chief electrician, who notes on it any comments or directions necessary and orders the work done.



WALWORTH MFG. COMPANY.

MOTOR INSPECTION REPORT DATE:- Nov-3-22

NOTES OF REPAIRS NECESSARY:-

Motor No 8020 - Wire to ground on front Vee ring, burnt off the end of two bars in two different places

REPAIRS MADE:

Motor No 8020 - Repairmen clears ground on Vee ring removed ground connection to frame Temporary repair only Note Commutator will need repairing (Mill reamed armature at same time commutator is replaced EJF

B. Felt
Inspector.

WALWORTH MFG. COMPANY.

CRANE INSPECTION REPORT Date:- Jan 3-23

(1) Steel Fdy crane needs new Brushes on bridge controller
(2) East yard crane needs 2 cross trolley wheels

REPAIRS MADE: Boiler House coal crane reset tension on hoist controller fingers.
Put one new segment on pipe Fabricating crane bridge cont

Wm DeBarre
Inspector

of the plant. The motors range in size from 1/40 hp. to 175 hp.; the majority is however, under 75 hp. and of the total number of motors 103 are rated under 5 hp.

Approximately one-half of the motors, 120, are connected directly, or through gearing to the machines which they drive; belt drive is employed with 115 motors, and chain drive with three.

In addition to the motors mentioned above there are ten traveling cranes, two small, narrow-gage electric locomotives and three industrial tractors.

The indoor lighting systems comprise a total of 3,800 Mazda lamps ranging from 50 to 500 watts, arranged for the most part for localized-general illumination. For yard lighting fifteen 1000-watt lamps are employed. The total lighting load amounts to 270 kw.

A staff of ten men, comprising one armature winder, one helper (who also acts as crane inspector), two motor inspectors, one night troubleman, two wiremen and two helpers and one lamp washer, is required in the electrical department to handle the inspection, repair and new construction work.

All Motors Are Inspected Once a Day

Failure of a motor may shut down an important machine or group of machines, causing a serious loss of production. Also, the prompt detection of trouble will often save expensive trips to the repair shop, and so a thorough-going inspection routine is in force. Two motor inspectors make a careful examination of every motor and its control equipment once a day. This inspection involves examination of bearings and field coils to detect undue heating, determining whether there is sufficient oil in the bearings, detection of brush or commutator trouble, examination of contact surfaces of switches and starters, and so on. Motors which are located in very dirty places, for example in the foundries, are blown out daily with compressed air, at a pressure of 35 lbs. per sq. in. All other motors are blown out once a month.

In like manner the oil in the bearings of motors in the foundries and other unusually dirty places is changed once a week. On the whole, the oil in the bearings of the other motors is changed when it begins to show dark.

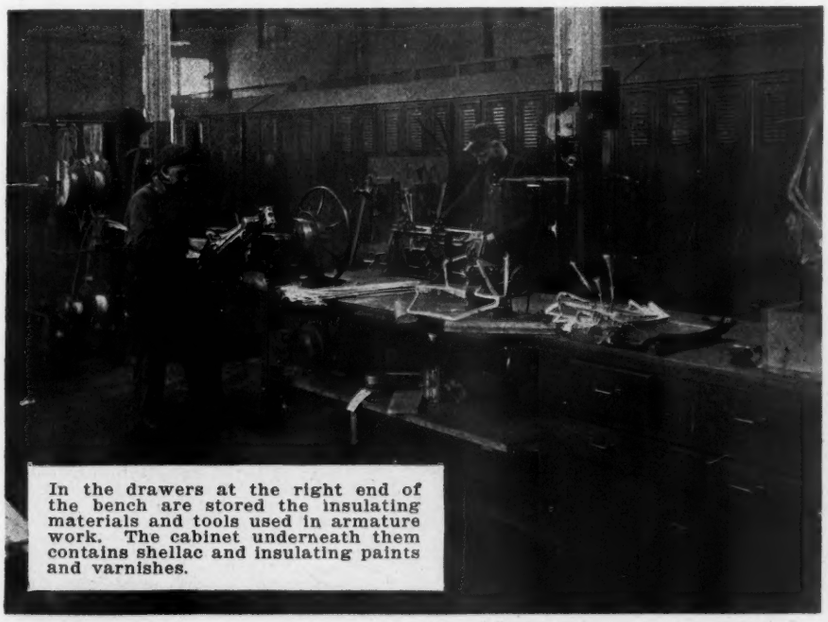
Another inspector is assigned to make a daily inspection of the cranes. He examines the motors, bearings, controller, driving pinions and shafts and so forth. Once a week he sounds the truck wheels with a hammer, to see if any of them are cracked.

As a check, the chief electrician inspects each motor once a week and the cranes once in two weeks.

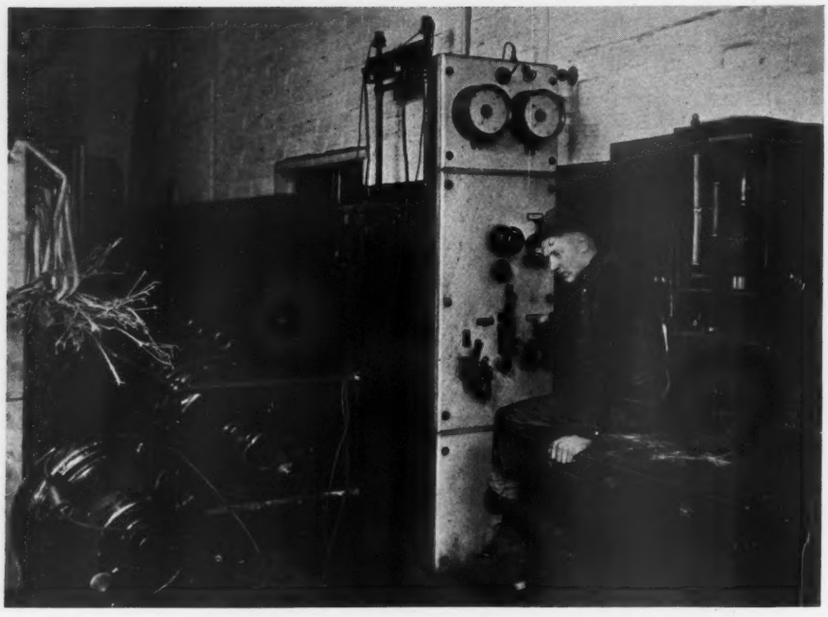
When examination shows that a motor or crane is in proper condition no report is made. If any trouble is discovered, however, the inspector fills out a *Crane Inspection Report* or *Motor Inspection Report*, as the case may be, describing the nature of the trouble and turns it over to the chief electrician. These report forms are shown in an accompanying illustration. The latter then marks on the report any com-

Armature coils are wound and pulled on this bench.

The equipment comprises a Segur coil winding machine, Segur taping machine, an Armature Equipment Co. spreader, and an insulation cutter, seen at the right. The coil winder and taping machines are driven by individual motors mounted under the bench. The reel rack can be seen at the left side of the illustration. The electrical supply store room is on the other side of the row of steel lockers, which are placed in approximately the center of the building, and enclose the repair shop on one side.



In the drawers at the right end of the bench are stored the insulating materials and tools used in armature work. The cabinet underneath them contains shellac and insulating paints and varnishes.



This is the high-voltage testing outfit and its control board.

The outfit consists of a 25-hp. 240-volt d.c. motor direct-connected to a 15-kva, 220-volt, 60-cycle, three phase a.c. generator, connected single-phase to the switchboard with a 1.25-kw. 125-volt exciter, and a 7-kw. transformer with a ratio of 10 to 1. From this switchboard there can be obtained 5 to 125 volts and 250 volts d.c., 5 to 220 volts, 60-cycle, 3-phase a.c. and 5 to 3000 volts, 60-cycle, single-phase, a.c. An electrically heated oven for baking small armatures is shown on the wall to the right.

ments or notes which he considers necessary and gives orders to have the work done. If it is desired to find the exact cost of a repair or installation job, or if one of the other departments requests that certain work be done, the superintendent of maintenance issues in triplicate a *Service Order* bearing a serial number, prefixed by the letter (*R*).

If the job is estimated to exceed a certain amount, the *Service Order* is issued by the works engineer and bears a number prefixed by the letter (*M*), for *Minor Appropriation*, approved by the general superintendent and the superintendent of maintenance.

The *Service Order* is then sent to the chief electrician, who renders the service called for. All *Job Time Cards* and *Stores Issue Cards* made out for the work in question must bear the letter and number of the *Service Order* authorizing the work.

If the *Electrical Department* finds it necessary to call on other departments, for example, having a commutator turned in the machine shop, for work in connection with the job, the order issued by the *Electrical Department* bears the number assigned to the original order. When the job is completed the order is marked O. K. by the chief electrician and returned to the superintendent of maintenance. The date on which the work was completed is marked on the file copy of the order and the original sent to the *Cost Department*, where the total cost of the work is charged against the department for which it was done.

Failure of motors and control equipment can hardly be eliminated altogether, but we have found that a careful inspection daily will reduce breakdowns, with their attendant loss of time and production, to a minimum.

The lighting system is also given the care necessary to keep it in good condition. Burned-out and blackened bulbs are replaced as soon as discovered and every lamp and reflector in the plant is washed once a month with soap and water.

Arrangement of Equipment in Repair Shop

The electrical repair shop proper occupies a space of 38 ft. by 26 ft. in one end of a building which was formerly used by one of the manufacturing departments, but has now been turned over to the electrical and steam fitting departments. As will be seen from the accompanying illustrations, there are two benches, one for light and the other for heavy work, along the outside wall, where full advantage can be taken of the daylight. These benches are 14 ft. long and 3 ft. wide; one, used for heavy work is 2½ ft. high, while the other is 3 ft. They are equipped with drawers 20 in. wide and 10 in. deep, which are assigned to the various members of the electrical depart-

SERVICE ORDER

KENT, MICH. WORKS

January 6th. 1923

TO Electrical Repair DEPT.

PLEASE FURNISH FOR Tapping DEPT.

DELIVER TO 1st. floor F.F. Building.

Rewind armature and make other necessary repairs on 75-H.P. Motor No. 8020 in Tapping Dept.

DATE REQUIRED February 1923.

APPROVED SIGNED Eng. Dept. BY

DIRECT CHARGE M-3255 ORDER NO.

All orders for Repairs, Replacement, Tools, Teaming and all Inter-Department Service must be made on this form; orders on Store Department excepted.

SERVICE ORDER

Kewanee WORKS

Jan-16 1923

Machine Repair DEPT.

PLEASE FURNISH FOR Electrical Repair DEPT.

DELIVER TO

Please turn commutator on 75 HP armature motor No 8020 Tapping Dept

DATE REQUIRED At once

APPROVED SIGNED E.J. Ford BY

DIRECT CHARGE M-3255 ORDER NO.

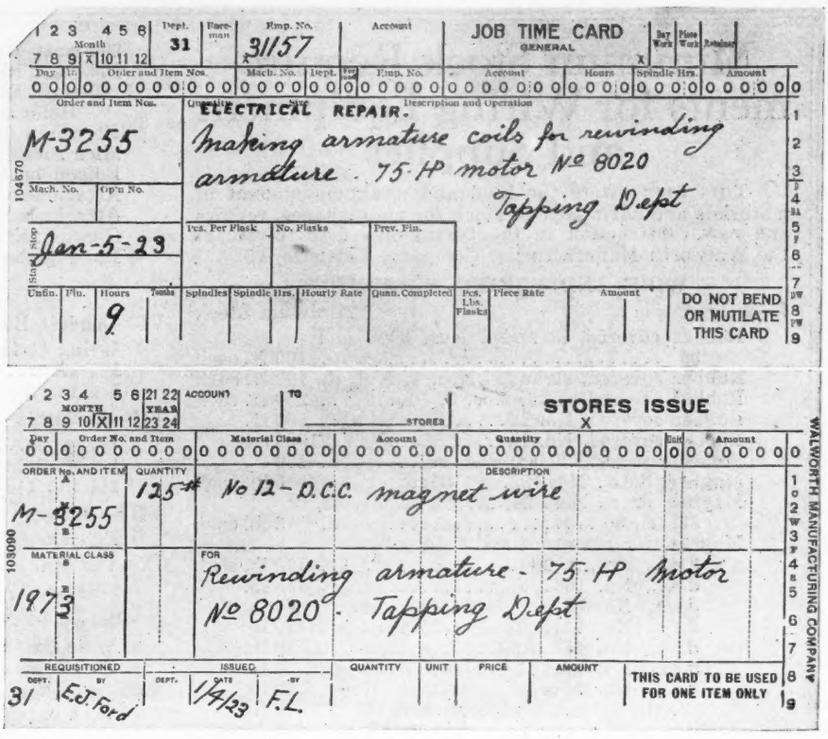
All orders for Repairs, Replacement, Tools, Teaming and all Inter-Department Service must be made on this form; orders on Store Department excepted.

All requests for service rendered by one department for another are made on this form.

The order on the left was issued by the *Engineering Department* to cover repairs necessary on a large motor in the *Tapping Department*. This order is issued in triplicate; the original goes to the department which will do the work, while one copy is filed in the department originating the order and the third in the office of superintendent of maintenance. The letter M prefixed to the number of the order (3255) shows that a *Minor Appropriation* has been made to cover the cost of the work. *Job Time Cards, Stores Issue Cards* and other *Service Orders* for work on this job must bear the number (M-3255) of the original order.

These cards record the time and material spent on a job.

On the *Job Time Card* (at top of illustration) the repairman puts down each day the time spent on the job and charges it against the number of the *Service Order*, M-3255 in this case. The material required for the job is drawn from the storeroom on the *Stores Issue Card*, which also bears the number, M-3255, of the *Service Order*. These cards are sent to the office daily until the job is completed. Then the total cost is figured in the Cost Department and entered under the order numbers.



ment. Each drawer is provided with a hasp and staple so that it can be locked with a padlock.

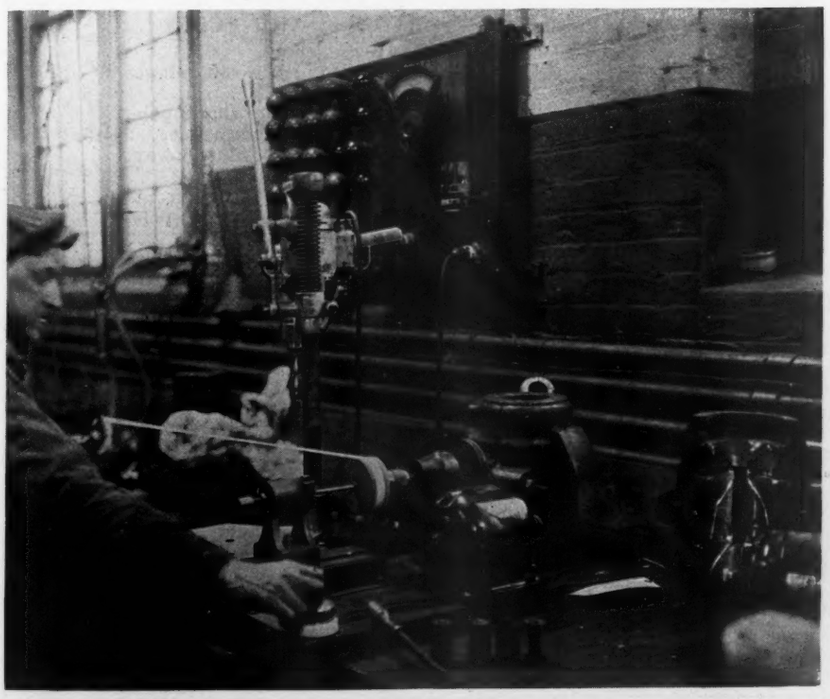
The benches are fitted with vises and a Black and Decker electric drill supported by a bench stand is mounted on one end of the bench used for light work. The other bench, which is used mostly by the armature winders, has on it a small gas furnace, for heating soldering irons and so on.

On the wall, above this bench, is a bank of twenty lamps used for testing purposes. By means of six switches any number of lamps from one to twenty can be thrown into circuit. An ammeter, mounted beside the lamps on the same board, indicates the amount of current flowing.

The test leads are run through ½-in. conduit which goes up for a distance of 14 ft. above the bench and is then bent at a right angle, to bring the end over the outer edge of the bench. A small pulley is suspended from the upper end of the conduit. The test leads, which are 30 ft. long, pass over this pulley and by means of a counterweight are drawn up and out of the way when not in use.

At one end of the shop is located a high-voltage testing outfit comprising a 25-hp., 240-volt d.c. motor direct-connected to a 15-kva., 220-volt, 60-cycle, three-phase a.c. generator with a 1.25-kw., 125-volt d.c. exciter, and a 7-kw. transformer, ratio 10:1. The generator is connected single-phase to, and controlled by, a switchboard provided with the necessary switches, circuit breaker and volt- and ammeter. High-tension test leads are brought out from the back of the board. This outfit can be used for making a wide variety of tests, inasmuch as it is possible to obtain from 5 to 125 volts and 250 volts direct current; from 5 to 220 volts, 60 cycles, 3-phase and from 5 to 3,000 volts, 60 cycles, single-phase.

A row of double steel lockers running down approximately the center of the building forms the opposite side of the shop and serves to cut it off from the rest of the building. A 14-ft. bench placed several feet away from and in front of these lockers contains the coil-making equipment. This consists of a Segur coil winder, a Segur taping machine, an Armature Equipment Co. coil spreader and an insulation cutter. The coil winder and taping machine are driven by motors mounted under the bench. One large and two small drawers at one end of the bench are used for storing the fishpaper, empire cloth and other insulating materials, and the drifts and other tools employed in armature work. A closed cabinet be-



Machine for winding magnets and small coils.

This device was made in the repair shop and consists of a spindle threaded at one end to take a small drill chuck and mounted in an old sewing machine head. The spindle is driven by a ⅛-hp. motor. When winding magnet coils, a headless screw is run into the core and then firmly gripped by the chuck. As shown here the machine is winding tape on small spools, for use in the coil tapping machine, in much less time than could be done by hand.

Minimum Stock Requirements for Wiring Equipment and Supplies

THIS LIST covers the kind and minimum amount of materials and parts kept in stock for maintenance, repairs and new construction in the twenty-nine departments of the Walworth Manufacturing Company, Kewanee, Ill.

WIRE AND WIRING EQUIPMENT

I—Wire	Minimum Stock
Rubber covered, stranded Nos. 0000 and 00	100 ft. each
Rubber covered, stranded Nos. 1, 2, 4, 6.	100 ft. each
Rubber covered, solid, Nos. 8, 10	250 ft. each
Rubber covered, No. 12	500 ft.
Rubber covered, No. 14	1000 ft.
Weather proof, 500,000 circ. mil	100 ft.
Magnet, d.c.c., Nos. 22, 24, 25	5 lb. each
Magnet, d.s.c., Nos. 26, 27, 28, 29, 31, 32, 33, 35, 36	3 lb. each
Magnet, for armature and field coils—	
d.c.c., Nos. 9, 18	100 lb. each
d.c.c., No. 10	175 lb.
d.c.c., No. 12	75 lb.
d.c.c., No. 14	10 lb.
d.c.c., No. 15	50 lb.
d.c.c., No. 17	75 lb.
d.c.c., No. 20	20 lb.
Single Cotton, enameled, Nos. 23, 27	10 lb.
Trolley, hand drawn bare, Nos. 00, 1, 4, 6	100 ft. each
Soft drawn bare copper, No. 00 (other sizes for other depts.)	25 ft.
Twin conductor—	
No. 18, super service flexible	50 ft.
No. 18, packing house cord	100 ft.
No. 18, drop cord	25 ft.
Annunciator cable, 6 wire	60 ft.
II—Wiring Equipment	
Wire connectors, Nos. 200, 201, 202, 203, 205	2 each
Steel armored conductor, flexible twin, No. 14	25 ft.
Malleable brackets	6
Wood brackets	6
Soldering lugs, 30, 60, 100 and 200-amp.	5 each
Cross arms, 2-pin, 4-pin, 6-pin	2 each
Cross arm pins, 1½ in. x 9 in. locust, corner	12
Cross arm pins, 1½ in. x 9 in. locust, straight line	12
Channel pins, ¾ in. No. 00 wire	10
Cable clamps, Matthews	6
Cross arm braces	6
Lightning arresters, type MP	3
Lightning arresters, type C	3
Flexible steel conduit, ¾ in., 1 in., 1¼ in.	10 ft. each
Comb. couplings for d.s. conduit, ¾ in., 1 in., 1¼ in.	4 each
Panel box connectors for d.s. conduit, ¾ in., 1 in., 1¼ in.	2 each
Elasticaps, No. 210	100

LIGHTING EQUIPMENT

III—Lamps	Minimum Stock
Mill type, 50-watt, 220 and 230-volt	50 each
Mazda C, 230-volt, 100, 200, 300 and 500-watt	10 each
Mazda C, 230-volt, 1000-watt	5
Mazda C, 230-volt, 500-watt	3
Headlight, 94-watt, 110-volt	2
IV—Mercury Lamp Repairs	
Clamp screws, No. 711	6
Shifter resistance for type P, lamps Nos. 1, 4, 5	2 each
Shifters for type P, lamp, old and new	2 each
V—Reflectors and Sockets (George Cutter Co.)	
200-watt RLM, dome	5
200-watt RLM, holder socket	5
200-watt RLM, hook	5
100-watt RLM	5
50-watt RLM	10
Holders for same	10
Porcelain floodlight sockets	2
Mica sockets	20
Edison base receptacles—porcelain	5
Attachment plugs, Hubbel	10
Attachment caps, Hubbel	10
Guards for mica sockets	5
Inner globe for blue-print machine	2

CONDUIT FITTINGS

VI—Conduit Bushings	
½ in., ¾ in., 1 in	10 each
1¼ in.	5
1½ in., 2 in	3 each
VII—Locknuts	
½ in.	10
¾ in., 1 in	5 each
1¼ in., 1½ in., 2 in	3 each
VIII—Hangers	
Efficiency	12
IX—Clamps	
I-Beam, ½ in.	25
X—Outlet Insulators	
½ in., ¾ in., 1 in., 1¼ in.	5 each
Outlet boxes	5

XI—Condulets (Crouse-Hinds)—Minimum stock of each in parenthesis:

A-13-	(10)	B -(3)	E-13	(5)	FE-13	(1)	LB-1100	(10)
A-22-	(3)	B -(3)	E-23	(2)	FE-23	(1)	LB-2200	(10)
A-32-	(3)	B -(3)	E-33	(2)	FE-33	(1)	LB-3300	(5)
A-43-	(2)	BE-(2)	E-43	(2)	FE-43	(1)	LB-4400	(5)
A-53-	(2)	BE-(2)	E-53	(2)	FE-53	(1)	LB-5500	(5)
A-63-	(2)	BE-(2)	E-63	(2)	FE-63	(1)	LB-6600	(3)

LR-1100	(5)	T-11100	(10)	X-111100	(2)	G-1101	(2)
LR-2200	(5)	T-22200	(10)	X-222200	(2)	GL-1101	(2)
LR-3300	(5)	T-33300	(5)	X-311300	(2)	GS-1108	(2)
LL-4400	(5)	T-44400	(3)			GSL-1108	(2)
LL-5500	(5)	T-55500	(1)			H-110	(2)
LL-6600	(5)	T-66600	(1)			JRG-1	(3)

C-1100	(3)	UN-11	(2)	V-8	(2)
C-2200	(3)	UN-22	(2)	V-9	(2)
UB-55	(2)			YC-11302	(3)
UB-66	(2)			Z-2302	(3)
				ZU-121302	(1)

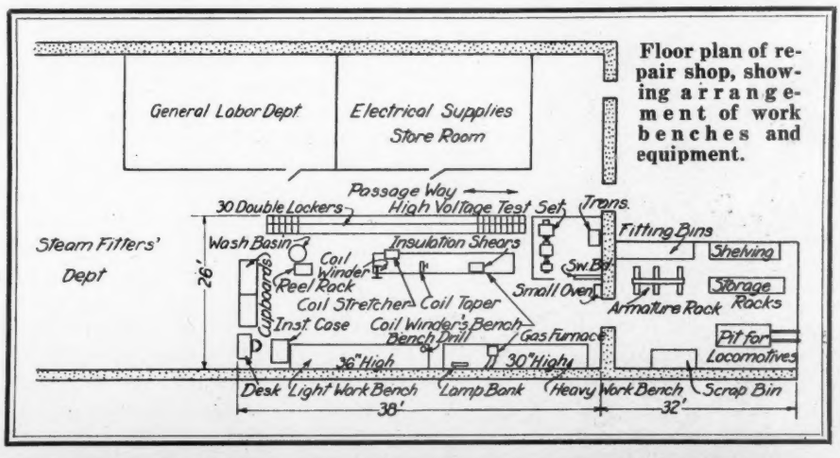
SWITCHES AND FUSES

XII—Switches	
Ceiling switches, 5-amp., 250-volt, single pole	5
Nickel snap, 5-amp., 250-volt, single-pole, open-base, wing turn, indicating	5
Nickel snap, 5-amp., 250-volt, 3-way, open-base, wing turn, indicating	2
Knife, Crouse-Hinds, single-throw, front-connected, 250-volt, double-pole, fusible, 30, 60, 100-amp	1 each
Knife, Crouse-Hinds, single-throw, double-pole, non-fusible, 100, 200, 400-amp.	1 each
Knife, Crouse-Hinds, single-throw, single-pole, non-fusible, 30, 60, 100, 200, 400-amp.	1 each
Safety enclosed, Crouse-Hinds, 30-amp., 250-volt, double-pole	1
XIII—Fuses (Economy Fuse & Mfg. Co.)	
Refillable, 250-volt, 6, 30, 60, 100-amp	10 each
Refillable, 250-volt, 100-amp	5 each
Refillable, 250-volt, 200, 400-amp	3 each
Refillable, 600-volt, 30, 60, 100-amp	6 each
Refillable, 600-volt, 200, 400-amp	3 each
Renewal links, 250-volt, 6-amp	500
Renewal links, 250-volt, 15, 20, 25, 30-amp.	200 each
Renewal links, 250-volt, 40, 50, 60, 80-amp.	100 each
Renewal links, 250-volt, 100, 125, 150, 200-amp.	25 each

Renewal links, 600-volt, 60, 100, 125, 150-amp.	10 each
Renewal links, 600-volt, 15, 20, 25, 30, 40, 50-amp.	25 each
XIV—Fuse Blocks, 2-wire, 30-amp., 250-volt..	5
INSULATION AND INSULATORS	
XV—Insulation	
Empire cloth	2 sq. yds.
XVI—Insulation	
Fish paper	3 lb.
Tape, ¾-in. linen armature	4 rolls
Tape, ¾-in. adhesive	20 lb.
Tape, rubber	2 rolls
Tape, ¾-in. No. 1 varnished	3 rolls
Mica bond, Chicago Mica Co., No. 101, .025, .030, .035	1 sheet each size
Mica bond, Chicago Mica Co., No. 104, .025, .030, .035	1 sheet each size
Uncut mica, grade A	1 lb.
Asbestos cord, ⅛ in	2 lb.
Cotton sleeving, No. 1 white	1 lb.
XVII—Insulators	
Strain insulators, 2000-volt	2
Strain insulators, little giant	5
Glass cable insulators	10
Glass insulators	10
Porcelain knobs, split, No. 5½	50
Porcelain knobs, solid, No. 1, No. 3½ (Overstock now)	
McIntire sleeves	4
Fiber tubes, 5/16 in. x 1/16 in. x 3 in...	25
XVIII—Miscellaneous	
Battery bells, 3-in	2
Push buttons, wood	2
Buzzer	1
Samson cells, carbons	4
Samson cells, lids	2
Samson cells, jars	2
Contact for Recti bells, top and bottom..	2 each
Leather nail heads	250
Heater plates	2
Lock washers, ⅜ in., ½ in., ⅝ in.	10 each
Carbon brushes (same as at present)	
XIX—Materials used but not stocked, in standard quantities:	
Wire—weather proof, Nos. 0000, 6, 8, 10	
Wire—magnet, d.c.c., Nos. 10, 11, 12, 17, 18	
Wire—resistance Climax, Nos. 16, 18	
Wire—annunciator, No. 18	
Circular loom, ⅜ in.	
Gang boxes, 4 in. x 4 in. and 4 in. x 6½ in.	
Sprague multiples for 1 in. conduit	
Porcelain tubes	
Porcelain cable insulators	
Annunciators, 3 and 10	
Carbons, for welding, several sizes	
Carbons, electrodes, several sizes	

low the drawers makes a convenient place for storing the cans of shellac and insulating paints and varnish. A shelf under the rest of the bench serves as a temporary storage place for paints, wire, and other materials.

A rack made of light angle iron and strongly braced is located a few feet from the end of the bench on which the coil winder is mounted, and is used for holding the reels of wire when coils are being wound.



Floor plan of repair shop, showing arrangement of work benches and equipment.

Between the reel rack and the row of lockers is a large wash basin.

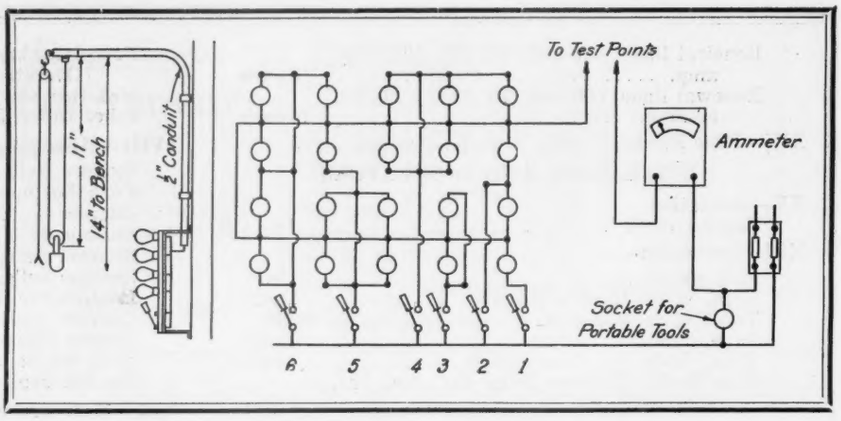
Running at a right angle to the lockers, and separating the repair shop from the steam fitters' department, is a row of steel cupboards in which are stored small miscellaneous repair supplies. In this corner of the shop is also placed the chief electrician's desk and a locked cabinet containing our equipment of portable volt-, watt- and ammeter and other delicate testing instruments.

Up to the present we have been using air drying varnishes (Ajax or Sterling) on large armatures after rewinding, while small armatures, up to 3 hp., were baked in a home-made oven, consisting of a cabinet made from asbesto-board and heated by several resistance units which were wound in the repair shop. This oven, which is mounted on the wall, is shown in one of the illustrations accompanying this article.

A small winding machine for making magnet and other small coils, winding tape for the taping machine, and so on, is the final item of our re-

Here is the stock of spare armature and crane parts.

Armatures are stored on heavy wooden racks, shown at the left. Normally there are on hand as spares, one 65-hp. armature, one 35 hp., one 23 hp., one 9 hp. and six or seven 3 hp. besides one armature for the electric locomotives and one for each crane motor. The shelves at the right contain a complete set of gears and pinions for crane motors, spare pulleys, starting boxes and other miscellaneous equipment which is too heavy and bulky to be stored in cabinets.



Wiring diagram of lamp bank for testing purposes.
This bank contains twenty 40-watt Mazda lamps, with six switches for control and ammeter for showing current flow when testing small motors and so on. The lamps and switches are connected so that any number of lamps from 1 to 20 can be put in circuit. Tne diagram at the left shows how the test leads are brought out through ½-in. conduit at the edge, and 14 ft. above the top, of the bench. After leaving the conduit the leads pass over a small pulley suspended from the end of the conduit. A counterweight keeps the leads, which have a reach of 30 ft., out of the way when not in use.

pair shop equipment. This was made from an old sewing machine head and pattern plate. The driving spindle is fitted with a small drill chuck, to hold screws or bolts screwed into the magnet cores. A ⅛-hp. motor furnishes the power for turning the spindle. No heavy machine work, such as turning shafts and commutators, is done in the repair shop; nor would it pay to install the necessary equipment for doing it. All such work is taken care of in the general machine shop, which is well equipped to handle anything in the way of machine work.

It is the intention, however, to install a gas- or electrically-heated oven which will be large enough to accommodate any armature we may have to rewind.

The variety and extent of the electrical equipment in this plant, and the fact that alterations or additions are constantly being made, render it necessary to keep in stock a considerable amount of material and parts. These are kept in steel racks approximately 18 ft. long and 12 ft. high. These racks are double; that is, both sides are alike, so that material can be stored from either side. As will be seen from the illustration, there are two rows of open bins at the bottom; then come three rows of drawers, one deep and two shallow. Above the drawers are four rows of bins. The bins are, of course, used for storing large and bulky articles, while the drawers are reserved for small parts. A list of the materials and parts, with the minimum amount kept in stock, is given elsewhere in this article.

Two such racks are required to hold the stock of parts usually kept on hand, and are located in a screen-inclosed general store room occupying about the same space as the repair shop.

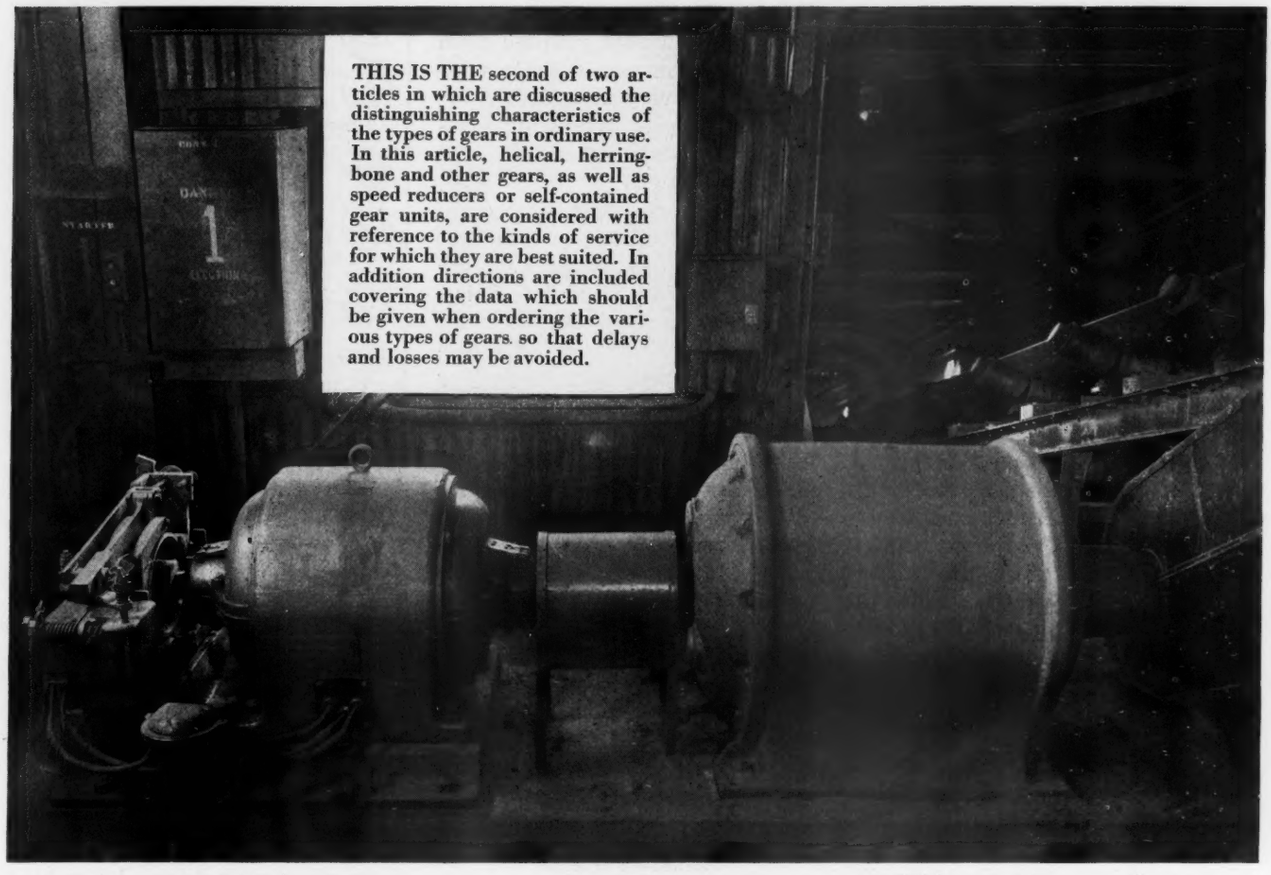
Spare motors, armatures, pinions and similar equipment is stored on racks and shelves in another section of the building, adjoining the repair shop but separated from it by a fire wall.

At the present time there is in stock one spare motor for the two electric locomotives and several other motors ranging in size from 3 to 25 hp. Inasmuch as trouble with our motors is usually located in the armature the following armatures are kept on hand: One 65-hp., one 34-hp., one 23-hp., one 9-hp. and six 3-hp., besides one armature for the electric locomotives and each crane motor.

These armatures, each is fitted with a set of new bearings, are stored on heavy wooden racks. Metal tags fastened to the racks, beside the armatures, give the size or the motor to which they belong.

A complete set of pinions and gears for each motor of the several cranes in use, together with spare pulleys, starting boxes and the like, are kept on shelving convenient to the armature racks.

Rack for storing supply of parts and materials.
Two racks like this are required to store the supply stock. These racks, which are 18 ft. long and 12 ft. high, are built double so that material can be stored from both sides and are home-made of light steel construction. The drawers are reserved for small parts, while bulky articles are placed in the open bins, above and below.



THIS IS THE second of two articles in which are discussed the distinguishing characteristics of the types of gears in ordinary use. In this article, helical, herringbone and other gears, as well as speed reducers or self-contained gear units, are considered with reference to the kinds of service for which they are best suited. In addition directions are included covering the data which should be given when ordering the various types of gears so that delays and losses may be avoided.

This is a 40-hp. speed-reducing set which drives a coke conveyor in a by-products coke plant. The speed reducer has a ratio of 40 to 1, giving, in this case, a final speed of 21.5 r.p.m.

Some Practical Information About

Gears and Speed Reducers

Together With Directions for Ordering Them That Will Help to Prevent Delays and Avoid Errors

By G. A. VAN BRUNT

Managing Editor, Industrial Engineer

IN AN article which appeared in the February, 1923, issue of INDUSTRIAL ENGINEER, practical details on the use of spur gears were discussed. Mention was made of the fact that although spur gears are extensively used, there are certain service and operating conditions which call for other types of gears. For instance, the teeth of spur gears make contact over their entire length, and the load is first thrown on the end of the tooth, producing a sudden and severe strain on the metal. Under such conditions the transmission of power through the gears is practically a series of impacts.

Helical Gears were developed, in part at least, to overcome this defect. Helical gears have oblique teeth, that is, teeth are placed at an angle to the axis of the gears. The form of tooth employed is the involute, or a close approximation to it. In well-made helical gears there is a greater amount of rolling action on the teeth than with ordinary spur gears of the same face, and the load is put on and removed slowly, so that shocks and severe strains are avoided. The chances of breakage are thus reduced and operation is more quiet.

Helical gears possess one disadvantage, however, in that they exert a more or less serious axial or side thrust, due to the action of the teeth. The thrust varies with the angle of the spiral; so the angle is made only large enough to insure the gradual and accurate meshing of a set of teeth while a preceding set is being released. This will be accomplished if the angle is such that the end of one tooth will just overlap the end of the adjoining tooth. The wider the face of a helical gear, therefore, the smaller the angle of spiral may be made, with a consequent reduction in side thrust produced.

One common method of overcoming this side thrust is to place two helical gears of opposite spiral on the same shaft, so that the thrust of one neutralizes that of the other. If necessary or desirable, they may be mounted some distance apart, or

they may be mounted or even bolted together to form what is known as a herringbone gear.

Herringbone Gears Are Suitable for Heavy Drives

Herringbone Gears are sometimes referred to as double helicals and virtually consist of two helical gears of opposite spiral in one face. They do not, therefore, produce any unbalanced axial thrust.

Cutting the teeth of herringbone gears presents certain mechanical difficulties and any one of several different procedures may be followed. For example, two helical gears of opposite spiral may be accurately finished on adjoining sides and firmly fastened together. Another method is to make the rim in two pieces each of which is one-half of the width of the face of the finished gear, and separate from the spider. The two halves of the rim are then cut as helical gears and assembled together on the spider. Herringbone gears may be made in one piece either by cutting a groove through the center of the face, so that the cutter can run out at the groove, or the teeth may be staggered, for the same purpose.

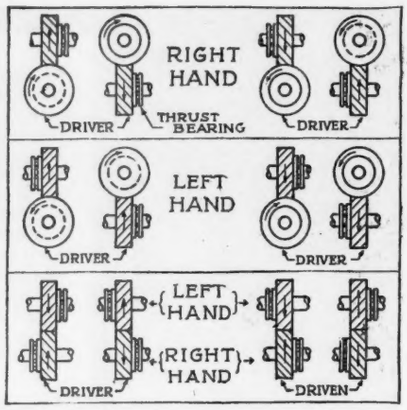
Comparatively small herringbone gears are capable of transmitting large amounts of power and also permit of greater single speed reduction than is possible with spur gears, because of the multiple tooth engagements and consequent safer meshing. In addition they operate with a minimum of noise and vibration. They find wide application, therefore, in the reduction of speed from motors and steam turbines. In addition, they are very satisfactory for and are much used on hoisting apparatus, rolling mill machinery and similar applications.

Internal Gears differ from ordinary spur and other gears in that the teeth are cut in the inner surface of the rim, instead of the outer. They can be obtained as plain rings for mounting in casings or otherwise, or provided with webbed or spoked backing the same as ordinary gears.

With internal gears the pinion and gear rotate in the same direction and they are largely used for speed reduction without reversal of direction of rotation, thereby saving one gear and its bearings. Other advantages are that as compared with spur and other gears the reduced shaft centers allow a greater speed reduction in the same space, also there is more bearing contact between the teeth, giving greater durability and steadier movement.

Bevel Gears Are Employed for Angular Drives

The preceding types of gears are employed for transmitting power between parallel shafts. There are many instances, however, where shafts in the same plane, but at an angle to each other, must be connected. For this purpose bevel gears are employed.



Direction of rotation and thrust of helical and spiral gears.

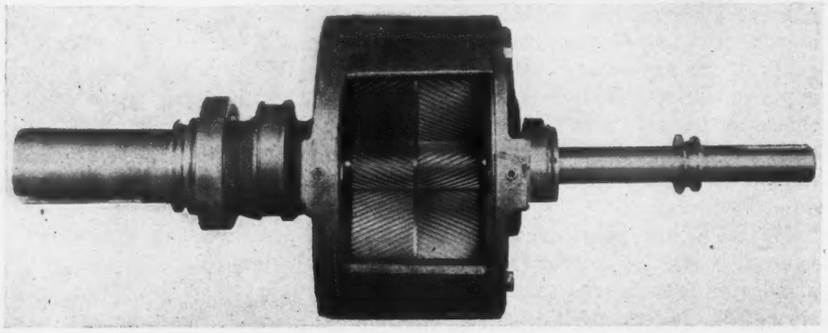
When the direction of rotation of the driver is known, the rotation of the driven gear can be determined from the diagram, which also shows where thrust bearings should be placed. This illustration is reproduced with acknowledgments to Boston Gear Works, Norfolk Downs, (Quincy), Mass.

Bevel Gears can be designed to operate at any angle, but are more often made for right-angle drives. Changing of speed is accomplished, as in other gear drives, by making one of the gears, called the pinion, smaller than the other. A pair of gears of the same diameter, running at right angles to each other, are generally known as miter gears.

The blanks or wheels on which bevel gear teeth are cut are of various forms, depending on the size of the gear, the material from which it is made, the service and so on. The pinion type of blank is used largely for gears having a small number of teeth and small pitch cone angle. For larger gears the web form is appropriate.

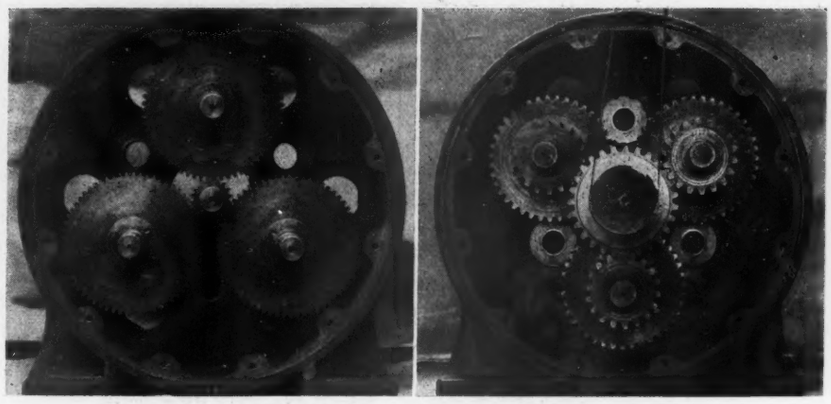
Bevel gears and pinions are made of cast iron, steel or brass, according to the service required. The smaller the pitch, the greater is the efficiency of a gear, provided that too wide a face is not required to transmit the power. When dealing with bevel and miter gears it must be remembered, however, that they are designed to operate in pairs and are not interchangeable, as are spur gears. A small miter will not run with a large miter, nor can a change of speed be effected by changing one of a pair of bevel gears.

The third condition under which power may have to be transmitted is when the shafts are at any angle



Working parts of one design of planetary speed reducer.

The upper illustration shows the lower half of the casing with the herringbone internal gear. The cage with the low speed shaft and intermediate gears, one has been removed here, and the high speed shaft and pinion are shown below. The internal gear is held rigidly in place by keys. As the high speed shaft revolves, its pinion rotates the intermediate gears which mesh with the internal gear. As the internal gear is stationary, the intermediate gears must rotate about the high speed shaft, causing the cage or low speed member in which they are mounted to rotate.



Interior view of one type of spur-gear speed reducer.

The left illustration shows the high-speed end of the reducer with the head removed, while a corresponding view of the low speed end is shown at the right. It will be seen that this make of reducer does not employ an internal gear. In operation a central driving pinion on the high speed shaft meshes with and drives three countershaft gears. Three pinions integral with these gears surround and drive another gear, which in turn drives three countershaft gears in the low-speed end. Three countershaft pinions integral with these gears drive the centrally-located, low-speed shaft. The high and low speed shafts are in line and rotate in the same direction. This is known as a double-type reducer and gives four reductions.

not in the same plane. Under these circumstances worm or spiral gears are employed.

Worm and Spiral Gears Connect Shafts Not in the Same Plane

Worm Drives comprise a worm provided with one or more continuous threads, somewhat like a screw thread, and a worm gear with which it meshes. The number of threads required for a worm is found by dividing the number of teeth in the worm gear by the velocity ratio desired. Thus, if a worm gear has sixty teeth and a velocity ratio of 30 to 1 is required, 60÷30=2, which is the number of threads required for the worm. For worm gear drives, "hand" means the direction of travel, either right or left, the same as for a screw. Lead means the distance which a given thread advances in one revolution of the worm. Pitch is the distance from center to center of two adjacent threads. The pitch and the lead are equal for a single-thread worm. For a double-thread worm the lead is twice the linear pitch, three times for a triple-thread and four times for a quadruple-thread. For example, a ½-in. pitch worm, quadruple-thread, would be 2-in. lead.

Worm gears are similar in general design and construction to spur gears. The face may be made either straight or concave. The teeth may be cut parallel to the axis of the worm gear, as in spur gears, or they may be cut at a small angle to the axis.

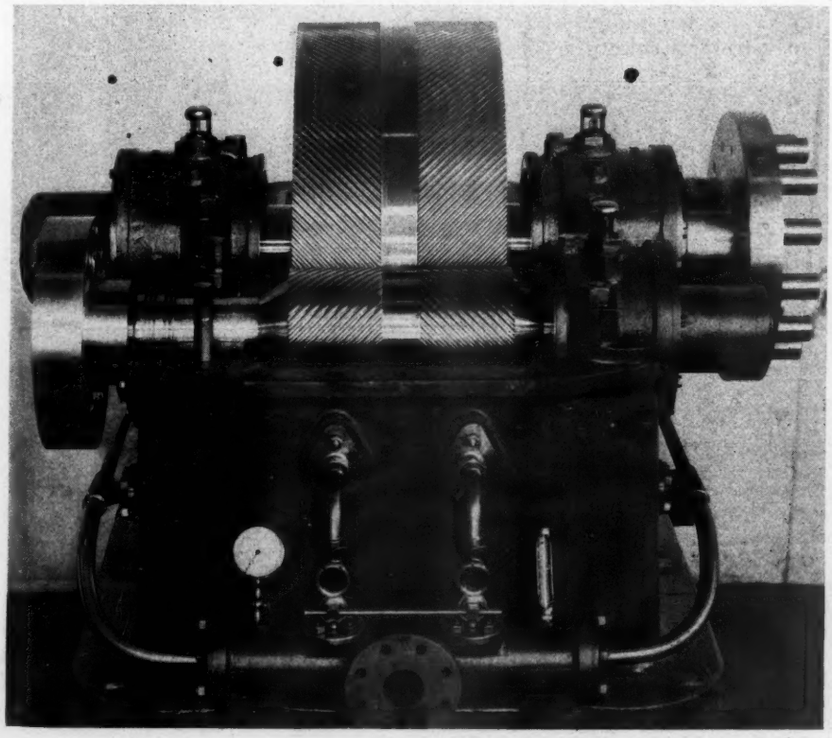
The materials from which the worm and gear are made have a good deal to do with the life and efficiency of a worm drive. The usual combination is a steel worm and a cast-iron cut worm gear, and for ordinary service gives good results. For high speeds or especially heavy duty a hardened steel worm and a phosphor-bronze worm gear are usually recommended.

It is important to note that the bearings for a worm drive must withstand both radial and thrust loads on the worm and usually the worm gear shaft also; a radial bearing must therefore be provided to support the worm and maintain it in the proper relation to the gear, while some form of thrust bearing must also be installed to take the thrust along the axis of the worm. This applies also to the wheel shaft.

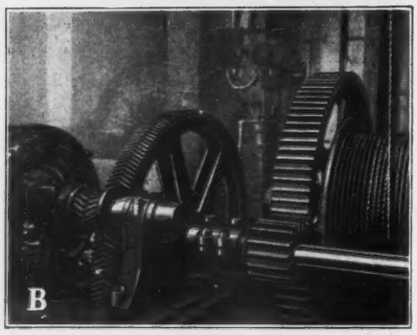
The efficiency and durability of a worm drive depend to a very large extent on the use of the proper lubricant in sufficient quantity to prevent heating and consequent undue wear. Although the action in a well-designed worm drive is largely a rolling contact between the worm threads and the wheel teeth, with as little sliding action as it is possible to obtain, it is necessary to use a lubricant which possesses sufficient body to form and maintain a film between the teeth, and still not be too heavy to flow properly. For the purpose of securing better lubrication and maintaining alignment, worm drives are usually mounted in oil-tight and dust-proof housings, the lower part of which is filled with oil so that the worm operates in a bath of lubricant.

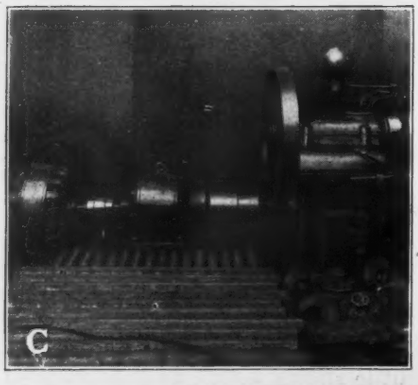
Worm drives have many applications where smoothness of action, large reductions in speed and increase in effective power are desired.

Spiral Gear is the term usually applied to gears which have angular teeth and the shafts or axes usually



Herringbone gear unit for driving centrifugal pump. This unit is rated at 825 hp., with a reduction of 3700 to 900 r. p. m.





Some Uses of
Gears and Gear Units
in Industrial Works

A—A speed reducer, ratio 6 to 1, eliminates one set of gears in the drive for this bleaching machine in the plant of Western Shade Cloth Co., Chicago, Ill.

B—Combination of herringbone and spur gears for speed reduction on hoisting drum. A herringbone gear runs more quietly and smoothly than a spur gear and makes the first reduction.

C—This speed reducer, ratio 10 to 1, takes the place of belts, shafts and pulleys for operating a 2-in. bolt cutter in shops of Union Draft Gear Co., Chicago, Ill.

D—An installation of speed reducers, ratio 17½ to 1, connected between motors and pumps in plant of Republic Chemical Co., Pittsburgh, Pa.

E—Saving space by using speed reducer, mounted overhead, in gas plant of Monongahela Valley Traction Co., Fairmont, W. Va.

F—A place where open gearing could hardly be used. This 3½-hp. speed reducer, ratio 140 to 1, drives a salt plunger feeder in a by-products coke plant.

G—Five-horsepower speed reducers, ratio 24 to 1, driving conveyor in plant of Stein-Hall Manufacturing Co., Chicago, Ill.

H—Another use for speed reducers in plant of Stein-Hall Manufacturing Co. Here is a battery of mixers driven through 7½-hp. reducers having a ratio of 22.4 to 1.

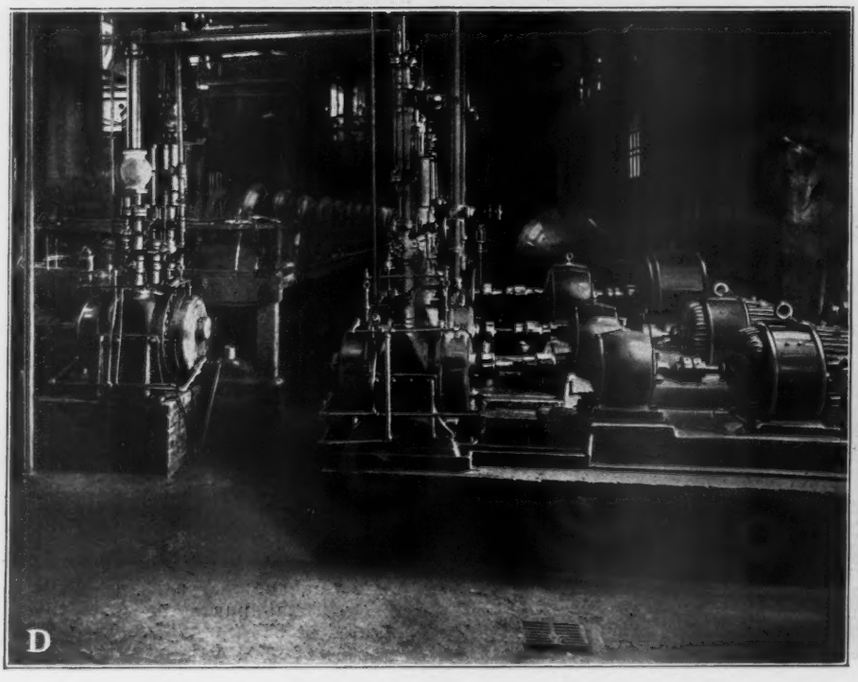
I—A compact and safe speed-reducing drive for billet-handling device in plant of The Pullman Co., Chicago, Ill.

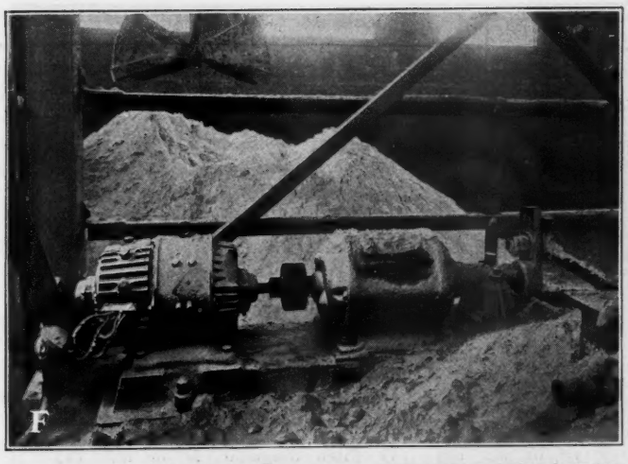
J—One way of obtaining the necessary reduction in speed. This is the drive for a dragline conveyor.

K—Here is another way of obtaining a reduction in speed—in this case from 1,800 r.p.m. to 138 r.p.m. This shows an ammonia compressor driven through a 15-hp. speed reducer.

L—A 5-hp. speed reducer, ratio 13.26 to 1, driving a belt conveyor feeding to a shaking screen in a by-products coke plant.

M—Little space is required by this speed-reducing drive for a slurry tank in a large cement mill. The reducer has a ratio of 4.8 to 1.

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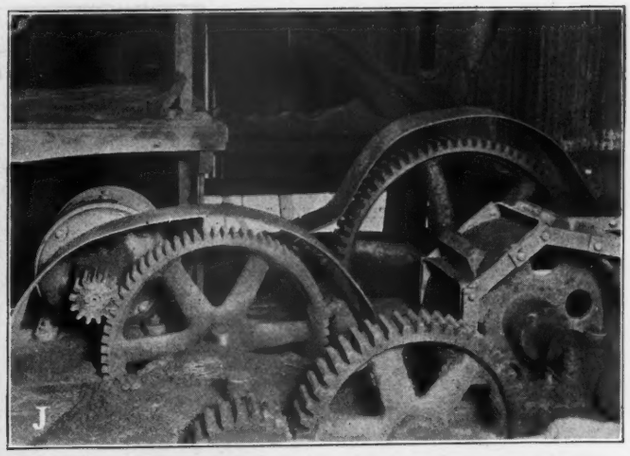
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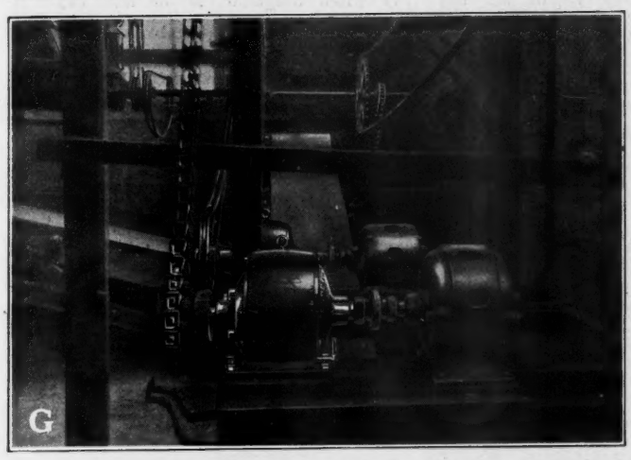
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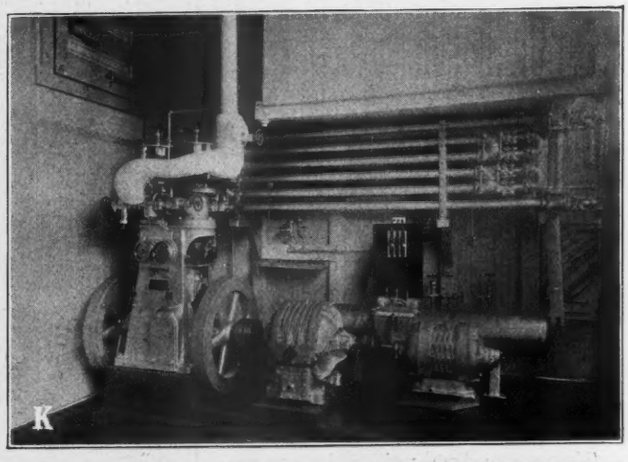
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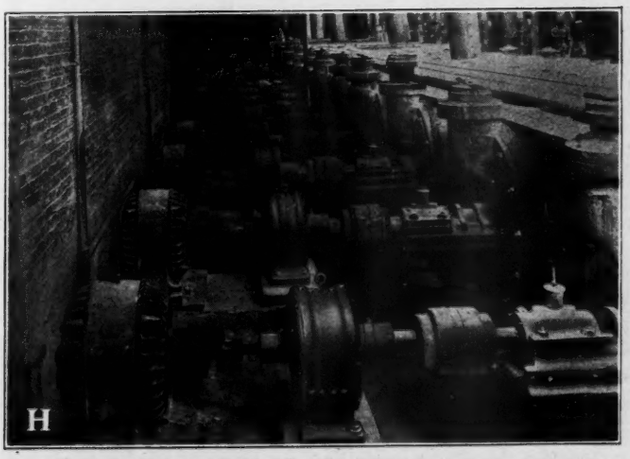
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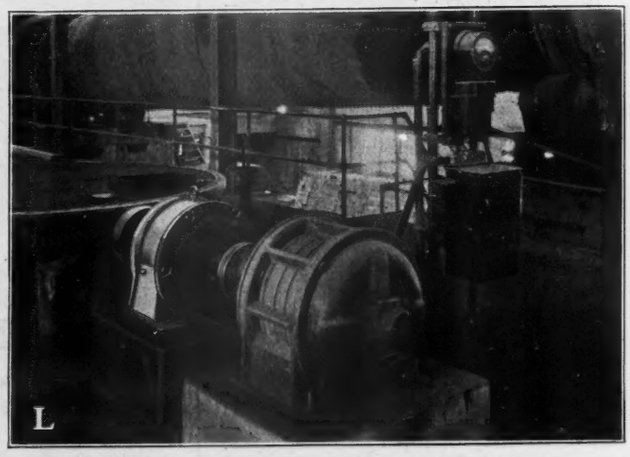
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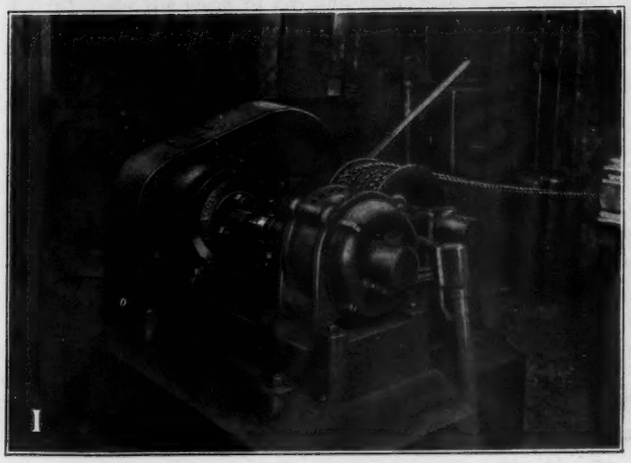
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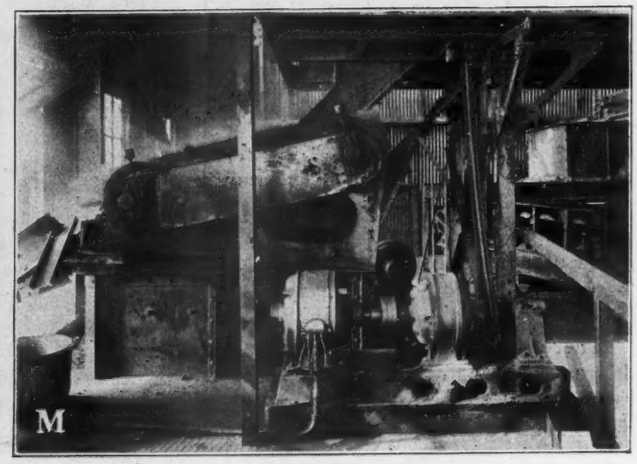

M

at right angles. Spiral gears can be used in place of bevel gears, and give smoother action as well as permit of a greater speed ratio within a given space.

When calculating speed ratios for spiral gears the driving gear may be considered as a worm having as many threads as there are teeth, and the driven gear regarded as the worm wheel with its number of teeth. One revolution of the driver will turn a point on the pitch circle of the driven gear as many inches as the lead of the teeth of the driver. Divide this by the circumference of the pitch circle of the driven gear to obtain the revolutions of the driven gear.

Spiral gears are usually made with a tooth angle of 45 deg. The required speed ratios can then be obtained by varying the diameter, as with spur or bevel gears. When the angles are not 45 deg. the gear with the greater angle must always be used as the driver. The two gears may both be cut right-hand or left-hand for operation at a right angle. If one gear is cut right-hand and the other left they can be used on parallel shafts.

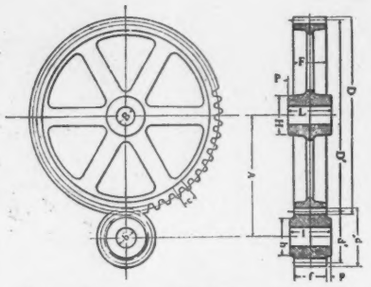
There are two points in connection with the use of spiral gears which sometimes cause confusion: the direction of rotation and the direction of the axial thrust. An accompanying diagram shows the direction of rotation for both right-hand and left-hand driver and driven gear and also the direction of the thrust.

Self-Contained Gear Units Often Take the Place of Open Gearing

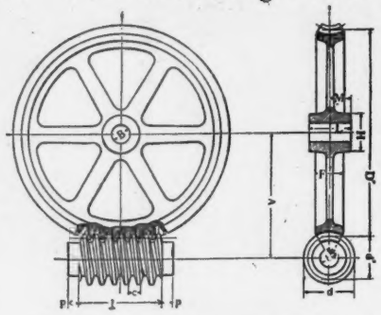
Under the best conditions, open gearing possesses certain objectionable features, such as the ever-present possibility of injury to employes, difficulty of proper lubrication, noise and the increased wear from dust and grit usually present in the air. With the rapid increase in the use of high-speed prime movers, electric motors and steam turbines, there has come a demand for compact and self-contained gear units which are quiet in operation, require the minimum of attention and will give the desired reduction or increase in speed.

There is now on the market a large number of so-called speed transformers, ranging from the fractional (*Continued on page 171.*)

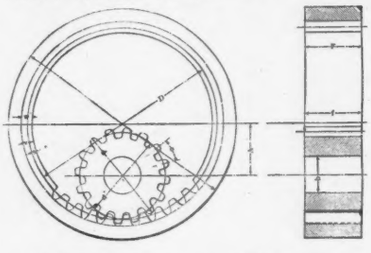
Data Which Should Be Given When Ordering Gears



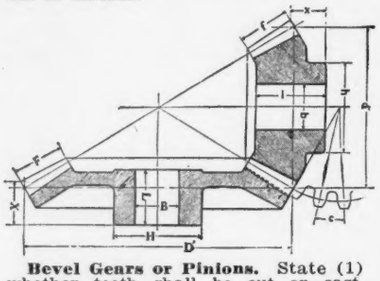
Spur Gears or Pinions. State (1) whether teeth shall be cut or cast. (2) Material. (3) Number of teeth. (4) Pitch diameter, *D′* or *d′*. (5) Width of face, *F* or *f*. (6) Pitch, circular, *C* or *c*, or diametral (number of teeth to each inch of pitch diameter). (7) Bore, *B* or *b*. (8) Whether keyseated or setscrewed. If keyseated, whether straight or taper. Give width and depth of keyseat. With taper keyseat where hub is not located centrally, state from which end of hub key drives. (9) Length of hub, *L* or *l*. (10) Projection of hub, *P* or *p*. (11) Diameter of hub, *H* or *h*. (12) Outside diameter, *D* or *d*. (13) Distance between centers, *A*.



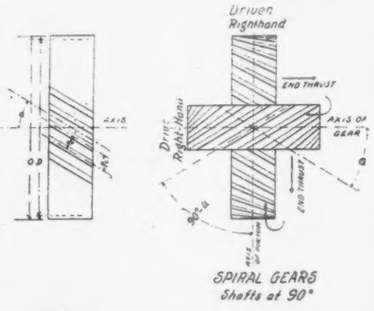
Worm Gears or Worms. State (1) whether teeth shall be cut or cast. (2) Material. (3) Number of teeth. (4) Pitch diameter, *D′* or *d′*. (5) Width of face, *F*. (6) Pitch, circular, *C* or *c*, or diametral (number of teeth to each inch of pitch diameter). (7) Bore, *B* or *b*. (8) Whether keyseated or setscrewed. If keyseated, whether straight or taper. Give width and depth of keyseat. With taper keyseat, state from which end of hub key is driven. (9) Length of hub, *L* or *l*. (10) Projection of hub. (11) Diameter of hub, *H* or *h*. Distance between centers, *A*. (12) Length of worm, whether right or left hand, and number of threads.



Internal Gears or Pinions. State (1) Material. (2) Number of teeth. (3) Pitch diameter, *D′* or *d′*. (4) Face, *F* or *f*. (5) Pitch, circular, *C* or *c*, or diametral (number of teeth to each inch of pitch diameter). (6) Rim diameter, *R*. (7) Outside diameter of pinion, *a*. (8) Bore of pinion, *b*. (9) Whether taper or straight keyway, width or depth. (10) Centers, *A*.



Bevel Gears or Pinions. State (1) whether teeth shall be cut or cast. (2) Material. (3) Number of teeth. (4) Pitch diameter, *D′* or *d′*. (5) Face, *F* or *f*. (6) Pitch, circular, *C* or *c*, or diametral (number of teeth to each inch of pitch diameter). (7) Bore, *B* or *b*. (8) Whether keyseated or setscrewed. If taper keyseat is used which end does key drive from? (9) Length of hub, *L* or *l*. (10) Backing, *X* or *x*. (11) Hub diameter, *H* or *h*.



Spiral, Helical and Herringbone Gears or Pinions. State (1) angle of tooth with axis of rotation, *a*. (2) Normal diametral pitch, *Pd*. (3) Circular pitch, *Pc*. This pitch varies with the angle of tooth. (4) Number of teeth in gear and in pinion. (5) Pitch diameter of gear, *D*, and pinion, *d*. (6) Outside diameter of gear, *O*, and pinion *o*. (7) Center distance, *C*. (8) Bore. (9) Whether keyseated or setscrewed. The sum of the tooth angles of a set of spiral gears with shafts at right angles must be 90 deg. The tooth angles of helical or herringbone gears are the same for both gear and pinion and can be made any angle to suit conditions. For a set of spiral gears, both must be right-hand or left-hand. In a set of helical gears, one must be right-hand and the other left-hand. Each of a set of herringbone gears is made of right and left-hand sections. When ordering herringbone gears with unequal hub projections state the hand for either section. The sizing of spiral gears differs from the sizing of spur gears on account of the angle of teeth. In spur gears, one diametral pitch, one inch is the addendum or diameter for one tooth. In spiral gears this addendum or diameter for one tooth is the secant of the angle of tooth. The secant of the angle of tooth, when divided by the diametral pitch to be used is the addendum for that pitch and when this addendum is multiplied by the number of teeth required, the product is the pitch diameter for that gear. The greater the angle of tooth, the larger the diameter of the gear.

GROUPING THE COILS of induction motors and connecting the groups for different series and parallel windings are two every-day jobs in every repair shop. This is the first of a series of articles in which Mr. Roe presents some diagrams and tables which help to make these jobs easy. He covers two-phase and three-phase windings of two to twenty-four poles. He explains the use of both long and short jumpers. He tells how many coils are placed in each group. This is an especially difficult thing to figure if the groups have unequal numbers of coils. By following his diagrams the job is made comparatively simple.

Tables and Diagrams for

Connecting Induction Motors

Showing How Coils Are Grouped and the Series and Parallel Connections Are Made

By A. C. ROE,

Shop Superintendent, Detroit Service Department, Westinghouse Electric and Manufacturing Company

IN connecting induction motors the main job revolves around the proper grouping of the coils and the connecting of these groups. In this series of articles I am going to take up just these things and discuss the step-by-step details from the viewpoint of the shop man who does the work. The complete series will cover two-phase and three-phase windings having from two poles to twenty-four poles. This range covers almost all of the cases that will arise in practice. The diagrams and the data include both the short jumper and the long jumper connections for windings with four poles to twelve poles. For all the other numbers of poles (from fourteen to twenty-four and also two poles) the information covers only the short jumper. This short jumper gives what is called throughout these articles a "top-to-top" connection in which the adjacent pole-phase groups are connected together. The long jumper gives what is called a "top-to-bottom" connection in which all similar pole-phase groups are connected together, that is, every alternate group. This means that all north poles are connected in series and from the last north pole a short jumper is used to connect to the south poles which are likewise in series. Where the windings have sixteen poles to twenty-four poles, a top-to-top connection only is given because on larger machines only the short jumper should ordinarily be used. The top-to-bottom jumpers would be quite long and awkward to handle. Of course there are a few cases when the long jumper is used for such machines.

On smaller machines the long jumper makes a neater appearing job and is easier to connect. Wherever the letters *T-T* appear in these diagrams this means that a top-to-top connection is shown. Likewise the letters *T-B* mean that a top-to-bottom connection is employed.

The Tables Tell How Many Coils Must Be in Each Group

In connecting an induction motor, the winding must first be connected into pole-phase groups. Therefore, the first operation that will be dealt with in this article will be how to determine the number of coils which must be in each group. Later on, the methods of connecting the groups together will be explained. The number of coils which should be connected together in each group is given in the *Main Table* and in the other tables which are designated as

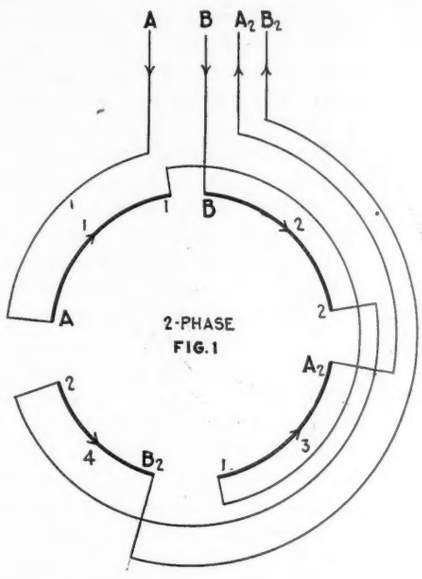
Main Table—Number of Coils Per Group in Winding

This table gives the number of coils in each group for windings having equal groups, that is, the same number of coils in each group. Each letter in this table indicates where equal groupings are not possible and that the unequal grouping will be found in other tables identified by those letters. A small (k) in this Main Table indicates that a coil must be killed in each group when this letter appears in this table. If this small (k) does not appear in this Main Table for the particular connection then no coil is killed even though the (k) is present in other tables. An asterisk (*) in this Main Table means that when consulting other tables which are referred to in this Main Table, the proper grouping will be found in the line in which an asterisk appears in conjunction with the figure which indicates the total number of coils. A blank space in this Main Table indicates that there is no practical grouping which can be made with the given number of coils and poles.

No. of Coils in Machine

No. of Poles	Connection / Phases	12	18	24	36	48	54	60	62	72	80	84	86	90	96	104	108	120	128	135	144	150	156	160	168	180	216	240	Phases / Connection	No. of Poles
2	Series	3 2	A 3	6 4	9 6	12 8	A 9	15 10	A B	14 12	20	21 14		15	24 16	26	27 18	30 20	32		36 24	25	39 26	40	42 28	45 30	54 36	60 40	Series	2
	2 Parallel	3 2	A 3	6 4	9 6	12 8	A 9	15 10	A B	14 12	20	21 14		15	24 16	26	27 18	30 20	32		36 24	25	39 26	40	42 28	45 30	54 36	60 40	2 Parallel	
4	Series	C 1	D	3 2	C 3	6 4	C D	C 5	C D	9 6	10 D	C 7	C D	C D	12 8	13 D	C 9	15 10	16 D	C D	18 12	C D	C 13	20 D	21 14	C 15	27 18	30 20	Series	4
	2 Parallel	C 1	D	3 2	C 3	6 4	C D	C 5	C D	9 6	10 D	C 7	C D	C D	12 8	13 D	C 9	15 10	16 D	C D	18 12	C D	C 13	20 D	21 14	C 15	27 18	30 20	2 Parallel	
	4 Parallel	1		3 2	C 3	6 4	C D	C 5	C D	9 6	10 D	C 7	C D	C D	12 8	13 D	C 9	15 10	16 D	C D	18 12	C D	C 13	20 D	21 14	C 15	27 18	30 20	4 Parallel	
6	Series	1	E 1	2 F	3 2	4 F	E 3	5 F	E F	6 4	E F	7 F	E F	E 5	8 F	E F	9 6	10 F	E F	E F	12 8	E F	13 F	E F	14 F	15 10	18 12	20 F	Series	6
	2 Parallel	1	E* 1	2 F	3 2	4 F	E* 3	5 F	E F	6 4	E F	7 F	E F	E* 5	8 F	E F	9 6	10 F	E F	E k F*	12 8	E* F	13 F	E F*	14 F	15 10	18 12	20 F	2 Parallel	
	3 Parallel	1		2	3 2	4	3	5	E	6 4	E k	7	E	5	8	E k	9 6	10	E k F	E k	12 8	E	13	E k	14	15 10	18 12	20	3 Parallel	
	6 Parallel	1	1	2	3 2	4	3	5	E	6 4	E k	7	E	5	8	E k	9 6	10	E k F	E k	12 8	E	13	E k	14	15 10	18 12	20	6 Parallel	
8	Series			G 1	G H	3 2	G H	G H	G H	G 3	5 H	G H	G H	G H	6 4	G H	G H	G 5	8 H	G H	9 6	G H	G H	10 H	G 7	G H	G 9	15 10	Series	
	2 Parallel			G 1	G H	3 2	G H	G H	G H	G 3	5 H	G H	G H	G H	6 4	G H	G H	G 5	8 H	G H	9 6	G H	G H	10 H	G 7	G H	G 9	15 10	2 Parallel	
	4 Parallel			G 1	G k H	3 2	G k	G k H	G k H	G 3	5	G k H	G k H	G H k	6 4	G k H	G k H	G 5	8 H k	G k H	9 6	G k	G k H	10 H	G 7	G k H	G 9	15 10	4 Parallel	8
	8 Parallel				G k	3 2	G k			G 3	5	G k	G k	G k	6 4	G H k	G k	G 5	8 H k	G k	9 6	G k	G k H	10 H	G 7	G k H	G 9	15 10	8 Parallel	
10	Series					K L	K L	3 2	K L	K L	4 L	K L	K L	K 3	K L	K L	K L	6 4	K L	K L	K L	K 5	K L	8 L	K L	9 6	K L	12 8	Series	10
	2 Parallel					K L	K L	3 2	K L	K L	4 L	K L	K L	K 3	K L	K L	K L	6 4	K L	K L k	K L	K 5	K L	8 L	K L	9 6	K L	12 8	2 Parallel	
	5 Parallel							3 2	K L	K k	4	K k	K k	3	K k	K k		6 4		K k L	K k	5		8		9 6	L k	12 8	5 Parallel	
	10 Parallel							3 2	K L	K	4	K	K	3	K	K		6 4		K	K	5		8		9 6	L k	12 8	10 Parallel	
12	Series				M 1	2 N	M N	M N	M N	3 2	M N	M N	M N	M N	4 N	M N	M 3	5 N	M N	M N	6 4	M N	M N	M N	7 N	M 5	9 6	10 N	Series	
	2 Parallel				M 1	2 N	M N	M N	M N	3 2	M N	M N k	M N k	M N	4 N k	M N	M 3	5 N k	M N	M N k	6 4	M N	M N	M N	7 N	M 5	9 6	10 N	2 Parallel	
	3 Parallel				M 1	2 N	M N	M	M N	3 2	M N	M N k	M N k	M N	4 N k	M k	M 3	5 N k	M N	M N k	6 4	M N	M N	M N	7 N	M 5	9 6	10 N	3 Parallel	12
	4 Parallel				M k 1	N		M k N	M k N	3 2	M	M k N	M k N	M k N	4 N	N k	M k 3	5 N	M N k	M k N k	6 4	M k N k	M k N		7 N	M k 5	9 6	10 N	4 Parallel	
	6 Parallel				M 1			M	M	3 2		M	M	M	4 N k		M 3	5 N	M N	M k	6 4	M k N k	M k N		7 N k	M 5	9 6	10 N k	6 Parallel	
	12 Parallel				M 1					3 2					4		M 3	5	M N	M	6 4	M k N k	M k N		7	M 5	9 6	10	12 Parallel	
14	Series				P	P X	P X	P X	P X	P X	P X	3 2	P X	P X	P X	P X	P X	P X	P X	P X	P X	P X	P X	P X	6 4	P X	P X	P X	Series	
	2 Parallel				P	P X		P X	P X	P X	P X	3 2	P X	P X	P X	P X	P X	P X	P X	P X	P X	P X	P X	P X	6 4	P X	P X	P X	2 Parallel	14
	7 Parallel											3 2	P X					P k	X						6 4				7 Parallel	
	14 Parallel											3 2	P X					P k	X						6 4				14 Parallel	
16	Series					R 1	R Y	R Y	R Y	R Y	R Y	R Y	R Y	R Y	3 2	R Y	R Y	R Y	4 Y	R Y	R 3	R Y	R Y	5 Y	R Y	R Y	R Y	R 5	Series	
	2 Parallel					R 1	R Y	R Y	R Y	R Y	R Y	R Y	R Y	R Y	3 2	R Y	R Y	R Y	4 Y	R Y	R 3	R Y	R Y	5 Y	R Y	R Y	R Y	R 5	2 Parallel	
	4 Parallel					R 1		Y	Y	R Y	R	Y	Y	R	3 2	R	Y	R Y	4		R 3		Y	5	R Y		Y	R 5	4 Parallel	16
	8 Parallel					1					R				3 2				4		R 3			5				R 5	8 Parallel	
	16 Parallel					1					R				3 2				4		R 3			5				5	16 Parallel	
18	Series				1	S	S 1	S Z	S Z	2 Z	S Z	S Z	S Z	S Z	S Z	S Z	3 2	S Z	S Z	S Z	4 Z	S Z	S Z	S Z	5 Z	6 4	S Z	Series	
	2 Parallel				1	S	S 1	S Z	S Z	2 Z	S	S Z	S Z	S Z	S Z	S k Z	3 2	S Z	S Z	S k Z	4 Z	S k Z	S Z	S	5 Z	6 4	S	2 Parallel	
	3 Parallel				1	S	S 1	S	S	2 Z	S	S Z k	S Z k	S Z	S	S	3 2	S Z	S Z	Z	4	S	S	S	5 Z	6 4	S	3 Parallel	18
	6 Parallel				1	S	1	S	S	2 Z		S	S	S			3 2	S Z		Z	4		S		5 Z	6 4	S	6 Parallel	
	9 Parallel				1		S 1			2 Z				S			3 2				4			S		6 4		9 Parallel	
	18 Parallel				1		1			2							3 2				4					6 4		18 Parallel	
20	Series					T	T	T 1	T J	T J	2 J	T J	T J	T J	T J	T J	T J	3 2	T J	T J	T J	T J	T J	4 J	T J	T 3	T J	6 4	Series	
	2 Parallel					T	T k	T 1	T J	T J	2 J	T J	T J	T k J	T J	T J	T J	3 2	T J	T k J	T J	T k J	T J	4 J	T J	T 3	T J	6 4	2 Parallel	
	4 Parallel					T		T 1	T J	T J	2	T J	T J	T	T J	T J	T J	3 2	T J	T	T J	T J	T J	4 J	T J	T 3	T J	6 4	4 Parallel	20
	5 Parallel							T 1	T J	T	2 2			J				3 2		J		J		4		T 3		6 4	5 Parallel	
	10 Parallel							T 1	T J		2 2			J				3 2				J		4		T 3		6 4	10 Parallel	
	20 Parallel							T	T		2			J				3 2				J		4		T 3		6 4	20 Parallel	
22	Series						V	V	V	V U	V U	V U	V U	V U	V U	V U	V U	V U	V U	V U	V U	V U	V U	V U	V U	V U	V U	Series	
	2 Parallel						V k	V	V	V U	V U	V U	V k U	V U	V k U	V U	V U	V U	V U	V U k	V U	V U	V U	V U	V U	V U	V U	2 Parallel	22
	11 Parallel													V k						V k U k						V k		11 Parallel	
	22 Parallel													V k														22 Parallel	
24	Series					1	W	W	W	W 1	W O	W O	W O	W O	2 O	W O	W O	W O	W O	W O	3 2	W O	W O	W O	W O	W O	W 3	5 O	Series	
	2 Parallel					1		W	W	W 1	W O	W O	W O	O	2 O	W O	W O	W O	W O	O k	3 2	W k O	W O	W O	W O	W O	W 3	5 O	2 Parallel	
	3 Parallel					1		W	W	W 1	W O	W	W	O	2 O	W O	W O	W	W O	O k	3 2	W k O k	W	W O	W	W O	W 3	5	3 Parallel	
	4 Parallel					1		W k		W 1	W	O	O		2 O		W k O	W O	W		3 2	W k O k	W k O	W O	W	W O	W 3	5 O	4 Parallel	24
	6 Parallel					1		W		W 1		W	W	O	2		W O	W	O	O k	3 2	W k O k	W		W	W O	W 3	5	6 Parallel	
	8 Parallel					1				W 1	W				2 O		O	W	W		3 2	W k O k		W			3	5 O	8 Parallel	
	12 Parallel					1				W 1					2						3 2	W k O k			W	W O	3	5	12 Parallel	
	24 Parallel					1				W 1					2						3 2	W k O k					3	5	24 Parallel	
No. Coils		12	18	24	36	48	54	60	62	72	80	84	86	90	96	104	108	120	128	135	144	150	156	160	168	180	216	240	No. Coils	

Two-Pole Windings



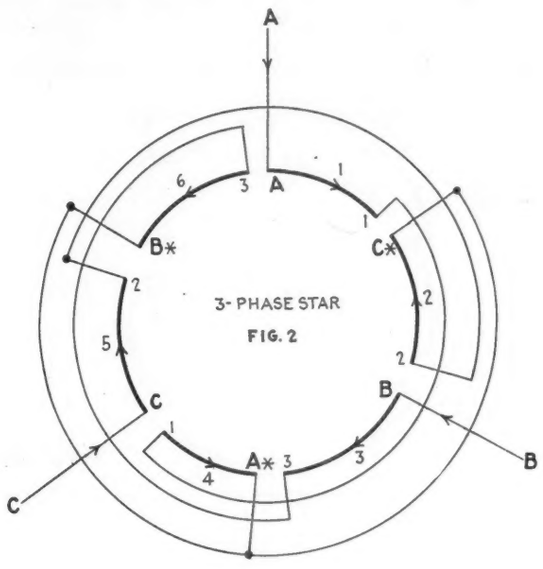


Chart A, Chart B, Chart C, etc. The *Main Table* gives directly the number of coils in each group if the winding is an "equal" winding. Throughout this discussion the term "equal" winding will mean that all of the coil-groups have the same number of coils. If the winding is an "unequal" winding (that is all the groups do not have the same number of coils) this fact will be indicated by a letter in the *Main Table* which will refer to one of the charts.

Therefore, the first thing to do in any case is to consult the *Main Table.* The columns in this table are arranged under the general heading of *Number of Coils in Machine.* The top row of figures refers to this heading and it should be remembered that the number of coils in the machine, and not the number of slots, is designated. Under each figure representing the number of coils, a sub-division is made according to whether the machine is two-phase or three-phase. This is indicated by the figures 2 and 3 in the second line of the *Main Table.* In the left-hand column of the table will be found the figures referring to the number of poles in a machine. And the second column will show the type of connection such as series, two-parallel, etc.

We can best explain the method of finding the number of coils per group by using an example. Suppose, for instance, that we have a motor with thirty-six coils and we want to connect it for six poles two-phase with a two-parallel connection. Then, we look under the figure 36 in the top line of the *Main Table* and in the left-hand column under this figure, as the left-hand column is for a two-phase connection. In this column to the right of the figure 6, which indicates six poles, and the two-parallel connection, we find that there is a figure 3. This figure 3 is seven lines down in the body of the table and seven lines over to the right. This figure indicates that all of the groups must have three coils. This is an equal winding.

Suppose now, we have the same winding with thirty-six coils and want to connect it for eight poles, two-phase in two-parallel connection. Reading down the same column as before, and over to the right from the eight poles and two-parallel designations, we find the letter *G.* When we find a letter such as this, we know that the grouping will be unequal and that we must consult the chart designated by the letter in order to find out how to arrange the groupings. In this case, we consult *Chart G.* In this chart the column at the left refers to the number of coils in the winding while the figures in the body of the table tell the number of coils in each group. Thus we see that in the first group there are two coils, in the second group two coils, in the third group two coils, in the fourth group two coils, in the fifth group two coils, and so on. This is the way that the coils should be connected in groups. It will be noticed that in some of the groups a small letter *k* appears above and to the right of the figure indicating the number of coils. This letter *k* may be disregarded unless a similar letter *k* appears also in the *Main Table*

UNEQUAL COIL GROUPING
TWO-POLE

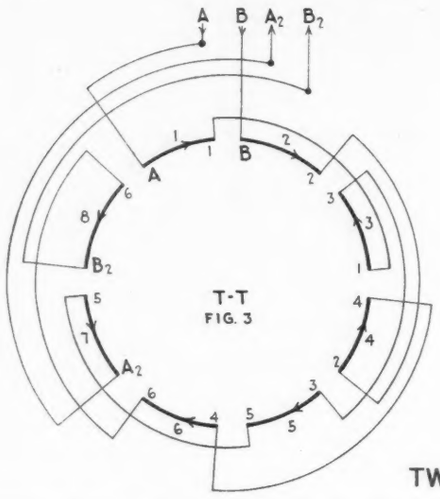
CHART A, TWO-PHASE					CHART B, THREE-PHASE						
No. Coils	Group No.				No. Coils	Group No.					
	1	2	3	4		1	2	3	4	5	6
18	4	5–1	5–1	4	62	10	10	11–1	10	11–1	10
54	13	14–1	14–1	13							
62	15	16–1	16–1	15							

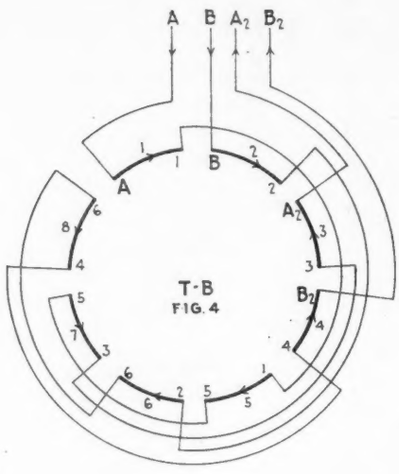
CONNECTIONS FOR ENDS OF GROUPS
OF TWO-POLE, THREE-PHASE MOTORS,
SEE FIG. 2.

Connect together group ends having same number or letter. Letters indicate line leads. A star connection is shown by (*).

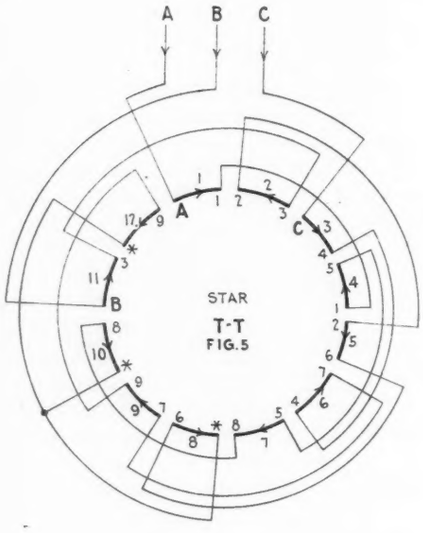
Group No.	1		2		3		4		5		6	
	T	B	T	B	T	B	T	B	T	B	T	B
Series Star	A	1	*	2	B	3	*	1	C	2	*	3
2 Parallel Star	A	*	*	C	B	*	*	A	C	*	*	B
Series Delta	A	1	B	2	B	3	C	1	C	2	A	3
2 Parallel Delta	A	C	B	C	B	A	C	A	C	B	A	B

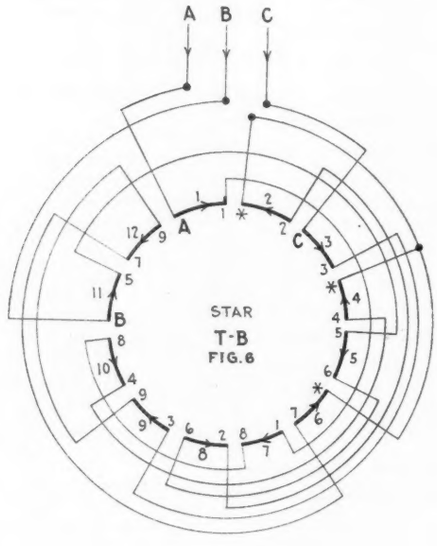
Four-Pole Windings

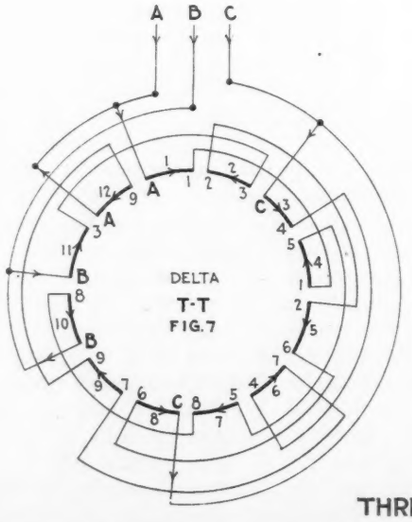


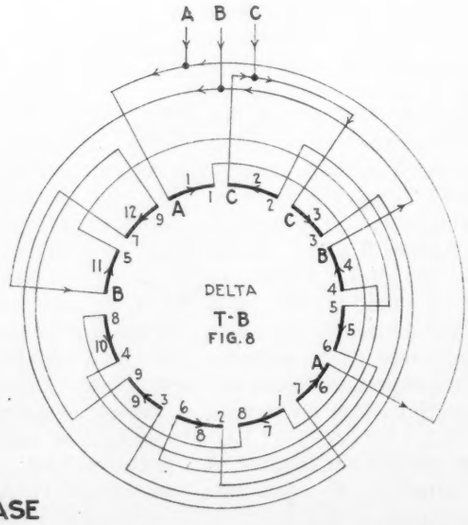


TWO-PHASE









THREE-PHASE

for the particular winding in question. As it does not appear for the eight-pole two-parallel winding it is disregarded in this case, and the figures given in *Chart G* are followed instead.

However, if this had been a four-parallel winding, leaving all other conditions the same it will be seen by consulting the *Main Table* that a small *k* appears with the letter *G*, as G^k. Therefore, this small *k* must be taken into account when grouping the coils according to *Chart G*. In each group where this small *k* appears one coil must be killed. This means that in groups 4, 5 and 6 a coil must be killed leaving only two coils in each of the groups.

In some cases the charts show a notation such as 3-1. This means that one coil must always be killed in such a group. A case of this kind is shown in *Chart H* in the left-hand table for the winding having 62 coils. The grouping according to this line of figures is as follows: 3, 3-1, 3, 2, 3, and so on. This means that the second group which is designated by 3-1 must be of three coils, one of which is killed.

In a few cases a star or asterisk (*) is shown in the *Main Table*. In this case, in the chart referred to by the letter in the *Main Table*, there are two rows of figures applying to the same number of coils. The second row of figures has at the left-hand end a star. This is the row of figures which must be used when the star appears in the *Main Table*. Where such a case occurs it means that a series connection may be used with this number of coils without killing any coils. However, when a parallel connection is wanted some of the coils must be killed and the method of doing this is indicated by the line in the chart in which the star appears.

As an example take a two-phase, six-pole motor having eighteen coils. For a series connection the *Main Table* has the notation *E*. For a two-parallel connection the notation is *E**. Looking under *Chart E* we see there are two lines for eighteen coils. One of the lines has an asterisk with the 18 as 18*. This is the line to use when making repairs on two-parallel windings.

Although the charts cover most of the cases met in ordinary repair work, it is well to explain how to figure out the unequal coil groupings for any case. The method of doing this will be explained in another article to appear later.

When the coils are already con-

Four-Pole Windings

UNEQUAL COIL GROUPING

TWO-PHASE, CHART C

Top-to-Top

Coils	Group Numbers							
	1	2	3	4	5	6	7	8
12	1	1	2	2	1	1	2	2
36	4	4	5	5	4	4	5	5
54	7–1	6	7	7	6	7–1	7	7
60	7	7	8	8	7	7	8	8
62	8–1	7	8	8	7	8–1	8	8
84	10	10	11	11	10	10	11	11
86	11–1	10	11	11	10	11–1	11	11
90	12–1	11	11	11	11	12–1	11	11
108	13	13	14	14	13	13	14	14
135	16	17–1	17	17	17–1	17–1	17	17
150	19–1	18	19	19	18	19–1	19	19
156	19	19	20	20	19	19	20	20
180	22	22	23	23	22	22	23	23

Top-to-Bottom

12	1	2	2	1	2	1	1	2
36	4	5	5	4	5	4	4	5
54	7–1	7	7	6	7	7–1	6	7
60	7	8	8	7	8	7	7	8
62	8–1	8	8	7	8	8–1	7	8
84	10	11	11	10	11	10	10	11
86	12–1	11	11	11	11	12–1	11	11

THREE-PHASE, CHART D

Top-to-Top

Coils	Group Numbers											
	1	2	3	4	5	6	7	8	9	10	11	12
18	2	1	2	1	2	1	1	2	1	2	1	2
54	4	5	4	5	4	5	5	4	5	4	5	4
62	6–1	5	5	5	5	5	5	6–1	5	5	5	5
80	6	7	7–1	7	6	7	7	7–1	7	6	7	6
86	7	7	8–1	7	7	7	8–1	7	7	7	7	7
90	7	8	7	8	7	8	8	7	8	7	8	7
104	8	9	9–1	9	8	9	9	9–1	9	8	9	8
128	10	11	11–1	11	10	11	11	11–1	11	10	11	10
135	12–1	11	11	11	12–1	11	11	11	12–1	11	11	11
150	12	13	12	13	12	13	13	12	13	12	13	12
160	14–1	13	13	13	14–1	13	13	13	14–1	13	13	14–1

Top-to-Bottom

18	2	1	2	1	2	1	2	1	2	1	2	1
54	4	5	4	5	4	5	4	5	4	5	4	5
62	6–1	5	5	5	5	5	5	6–1	5	5	5	5
80	6	7	7–1	7	6	7	7–1	7	6	7	6	7
86	7	7	8–1	7	7	7	8–1	7	7	7	7	7
90	7	8	7	8	7	8	7	8	7	8	7	8
104	8	9	9–1	9	8	9	9–1	9	8	9	8	9
128	10	11	11–1	11	10	11	11–1	11	10	11	10	11
135	12–1	11	11	11	12–1	11	11	11	12–1	11	11	11
150	12	13	12	13	12	13	12	13	12	13	12	13
160	14–1	13	13	13	14–1	13	13	13	14–1	13	13	14–1

CONNECTIONS FOR ENDS OF GROUPS

Connect together group ends having same number or letter. Line leads are indicated by letters. A star connection is shown by (*).

TWO-PHASE

Top-to-Top. See Fig. 3.

Group No.	1		2		3		4		5		6		7		8	
	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B
Series	A	1	B	2	3	1	4	2	3	5	4	6	A_2	5	B_2	6
2 Parallel	A	1	B	2	A_2	1	B_2	2	A	5	B	6	A_2	5	B_2	6
4 Parallel	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2	A_2	A	B_2	B

Top-to-Bottom. See Fig. 4.

Series	A	1	B	2	A_2	3	B_2	4	1	5	2	6	3	5	4	6
2 Parallel	A	1	B	2	A_2	3	B_2	4	1	A_2	2	B_2	3	A	4	B
4 Parallel	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2	A_2	A	B_2	B

THREE-PHASE

Star, Top-to-Top. See Fig. 5.

Group No.	1		2		3		4		5		6		7		8		9		10		11		12	
	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B
Series	A	1	2		3	C	4	5	1	2	6	7	4	5	8	*	6	7	9	*	8	B	3	*	9
2 Parallel	A	1	*		3	C	4	*	1	B	6	*	4	A	8	*	6	C	9	*	8	B	3	*	9
4 Parallel	A	*	*		B	C	*	*	A	B	*	*	C	A	*	*	B	C	*	*	A	B	*	*	C

Star, Top-to-Bottom. See Fig. 6.

Series	A	1	*	2	C	3	*	4	5	6	*	7	1	8	2	6	3	9	4	8	B	5	7	9
2 Parallel	A	1	*	2	C	3	*	4	5	*	*	7	1	*	2	B	3	*	4	A	B	5	7	C
4 Parallel	A	*	*	B	C	*	*	A	B	*	*	C	A	*	*	B	C	*	*	A	B	*	*	C

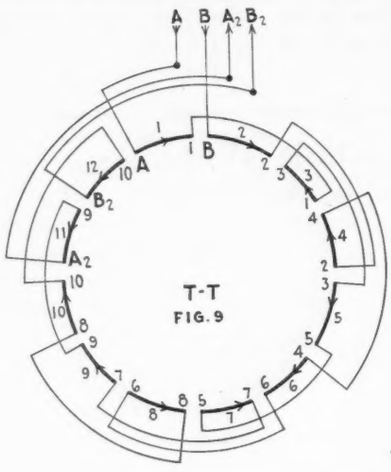
Delta, Top-to-Top. See Fig. 7.

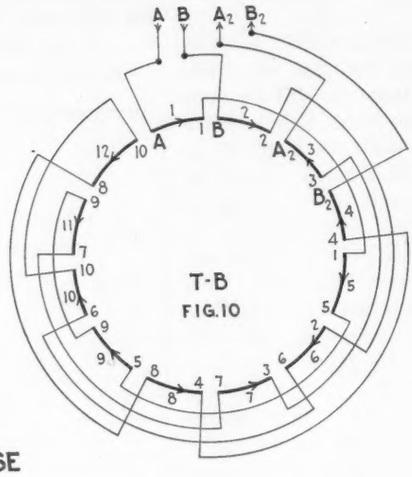
Series	A	1	2		3	C	4	5	1	2	6	7	4	5	8	C	6	7	9	B	8	B	3	A	9
2 Parallel	A	1	C		3	C	4	B	1	B	6	A	4	A	8	C	6	C	9	B	8	B	3	A	9
4 Parallel	A	B	C		B	C	A	B	A	B	C	A	C	A	B	C	B	C	A	B	A	B	C	A	C

Delta, Top-to-Bottom. See Fig. 8

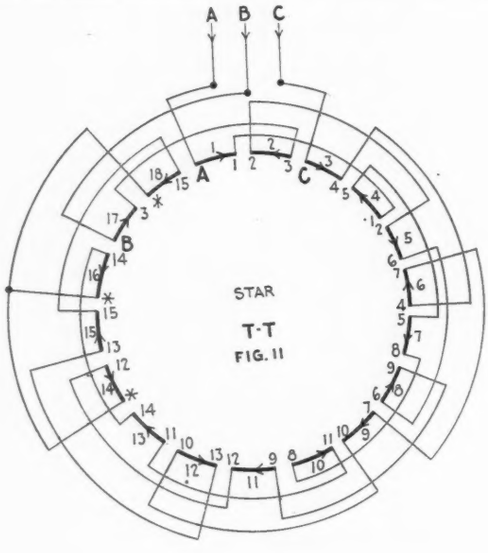
Series	A	1	C	2	C	3	B	4	5	6	A	7	1	8	2	6	3	9	4	8	B	5	7	9
2 Parallel	A	1	C	2	C	3	B	4	5	C	A	7	1	B	2	B	3	A	4	A	B	5	7	C
4 Parallel	A	B	C	B	C	A	B	A	B	C	A	C	A	B	C	B	C	A	B	A	B	C	A	C

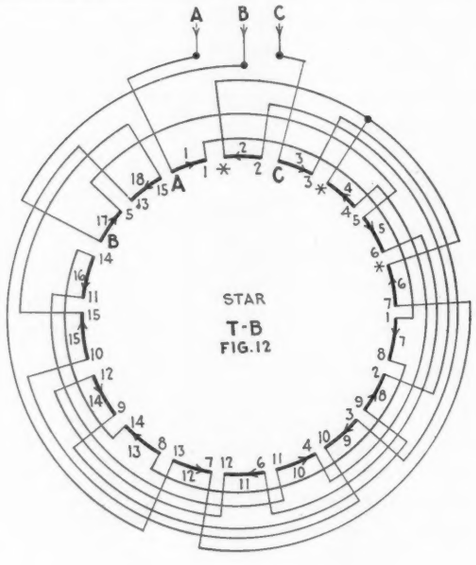
Six-Pole Windings

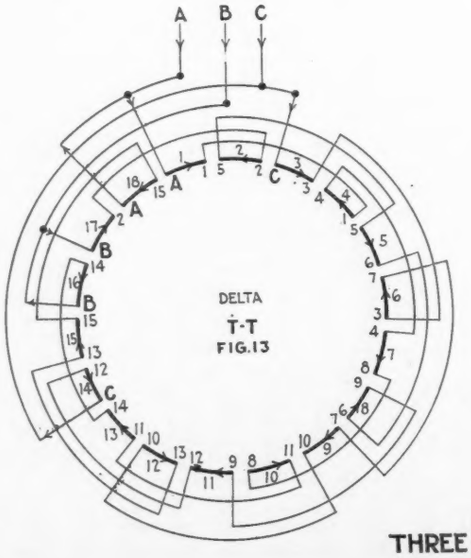


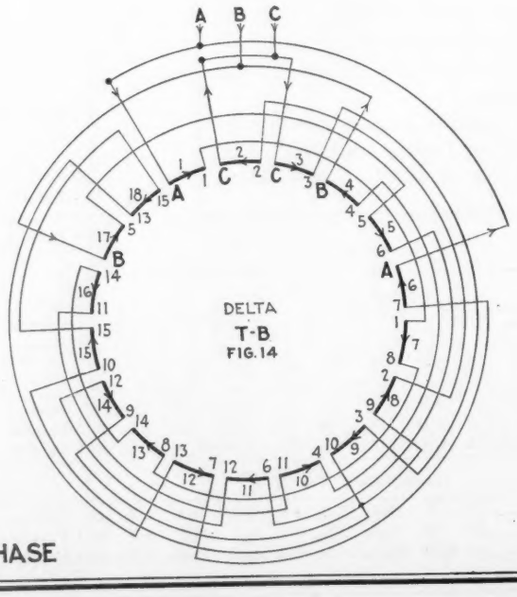


TWO-PHASE









THREE-PHASE

Six-Pole Windings

These Tables refer to accompanying diagrams marked figures 9 to 14 inclusive and to the discussion on unequal coil grouping.

CONNECTIONS FOR ENDS OF GROUPS

Connect together group ends having same number or letter. Line leads are indicated by letters. A star connection is indicated by (*).

Two-Phase, Top-to-Top. See Fig. 9.

Group No.	1		2		3		4		5		6		7		8		9		10		11		12	
	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B
Series	A	1	B	2	3	1	4	2	3	5	4	6	7	5	8	6	7	9	8	10	A_2	9	B_2	10
2 Parallel	A	1	B	2	3	1	4	2	3	A_2	4	B_2	7	A	8	B	7	9	8	10	A_2	9	B_2	10
3 Parallel	A	1	B	2	A_2	1	B_2	2	A	5	B	6	A_2	5	B_2	6	A	9	B	10	A_2	9	B_2	10
6 Parallel	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2	A_2	A	B_2	B

Two-Phase, Top-to-Bottom. See Fig. 10

Series	A	1	B	2	A_2	3	B_2	4	1	5	2	6	3	7	4	8	5	9	6	10	7	9	8	10
2 Parallel	A	1	B	2	A_2	3	B_2	4	1	5	2	6	3	7	4	8	5	A_2	6	B_2	7	A	8	B
3 Parallel	A	1	B	2	A_2	3	B_2	4	1	A_2	2	B_2	3	A	4	B	A	9	B	10	A_2	9	B_2	10
6 Parallel	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2	A_2	A	B_2	B

Three-Phase Star, Top-to-Top. See Fig. 11.

Group No.	1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B
Series	A	1	2	C	4	5	1	2	6	7	4	5	8	9	6	7	10	11	8	9	12	13	10	11	14	*	12	13	15	*	14	B	3	*	15	
2 Parallel	A	1	2	C	4	5	1	2	*	7	4	5	*	9	B	7	*	11	A	9	12	13	C	11	14	*	12	13	15	*	14	B	3	*	15	
3 Parallel	A	1	*	3	C	4	*	1	B	6	*	4	A	8	*	6	C	10	*	8	B	12	*	10	A	14	*	12	C	15	*	14	B	3	*	15	
6 Parallel	A	*	*	B	C	*	*	A	B	*	*	C	A	*	*	B	C	*	*	A	B	*	*	C	A	*	*	B	C	*	*	A	B	*	*	C

Three-Phase Star, Top-to-Bottom. See Fig. 12.

Series	A	1	*	2	C	3	*	4	5	6	*	7	1	8	2	9	3	10	4	11	6	12	7	13	8	14	9	12	10	15	11	14	B	5	13	15
2 Parallel	A	1	*	2	C	3	*	4	5	6	*	7	1	8	2	9	3	10	4	11	6	*	7	13	8	*	9	B	10	*	11	A	B	5	13	C
3 Parallel	A	1	*	2	C	3	*	4	5	*	*	7	1	*	2	B	3	*	4	A	B	12	7	C	A	14	*	12	C	15	*	14	B	5	*	15
6 Parallel	A	*	*	B	C	*	*	A	B	*	*	C	A	*	*	B	C	*	*	A	B	*	*	C	A	*	*	B	C	*	*	A	B	*	*	C

Three-Phase Delta, Top-to-Top. See Fig. 13.

Series	A	1	5	2	C	3	4	1	5	6	7	3	4	8	9	6	7	10	11	8	9	12	13	10	11	14	C	12	13	15	B	14	B	2	A	15
2 Parallel	A	1	5	2	C	3	4	1	5	C	7	3	4	B	9	B	7	A	11	A	9	12	13	C	11	14	C	12	13	15	B	14	B	2	A	15
3 Parallel	A	1	C	2	C	3	B	1	B	6	A	3	A	8	C	6	C	10	B	8	B	12	A	10	A	14	C	12	C	15	B	14	B	2	A	15
6 Parallel	A	B	C	B	C	A	B	A	B	C	A	C	A	B	C	B	C	A	B	A	B	C	A	C	A	B	C	B	C	A	B	A	B	C	A	C

Three-Phase Delta, Top-to-Bottom See Fig. 14.

Series	A	1	C	2	C	3	B	4	5	6	A	7	1	8	2	9	3	10	4	11	6	12	7	13	8	14	9	12	10	15	11	14	B	5	13	15
2 Parallel	A	1	C	2	C	3	B	4	5	6	A	7	1	8	2	9	3	10	4	11	6	C	7	13	8	B	9	B	10	A	11	A	B	5	13	C
3 Parallel	A	1	C	2	C	3	B	4	5	C	A	7	1	B	2	B	3	A	4	A	B	12	7	C	A	14	C	12	C	15	B	14	B	5	A	15
6 Parallel	A	B	C	B	C	A	B	A	B	C	A	C	A	B	C	B	C	A	B	A	B	C	A	C	A	B	C	B	C	A	B	A	B	C	A	C

UNEQUAL COIL GROUPING

TWO-PHASE, CHART E
Top-to-Top Connections

Coils	Group Numbers											
	1	2	3	4	5	6	7	8	9	10	11	12
18	2	2	1	1	2	2	1	1	2	2	1	1
*18	2–1	1	2	2	1	1	1	2–1	2	2	1	1
54	4	4	5	5	4	4	5	5	4	4	5	5
*54	5–1	4	5	5	4	4	4	5–1	5	5	4	4
62	6–1	5	5	5	5	5	5	6–1	5	5	5	5
80	6	7	7	6	7	7k	6	7	7	6	7k	7
86	8–1	7	7	7	7	7	7	8–1	7	7	7	7
90	7	7	8	8	7	7	8	8	7	7	8	8
*90	8–1	7	8	8	7	7	7	8–1	8	8	7	7
104	8	9	9	9k	9	8	8	9	9k	9	9	8
128	10	11	11	11k	11	10	10	11	11k	11	11	10
135	12k	11	11	11	12–1	11	11	12k	11	11	11	11
150	12	12	13	13	12	12	13	13	12	12	13	13
*150	13–1	12	13	13	12	12	12	13–1	13	13	12	12
160	14k	13	13	14k	13	13	14k	13	13	14k	13	13

THREE-PHASE, CHART F
Top-to-Top and Top-to-Bottom

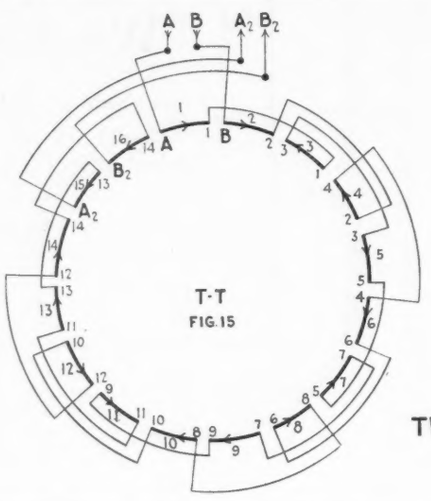
Coils	Group Numbers																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
24	2	1	1	1	1	2	1	2	1	2	1	1	1	1	2	1	2	1
48	2	3	3	3	3	2	3	2	3	2	3	3	3	3	2	3	2	3
60	4	3	3	3	3	4	3	4	3	4	3	3	3	3	4	3	4	3
62	4	3	3	3	3	4	4–1	4	3	4	3	3	3	3	4	3	4	4–1
80	5	4	4	4	4	5	5–1	5	4	5	4	4	4	4	5	4	5	5–1
84	4	5	5	5	5	4	5	4	5	4	5	5	5	5	4	5	4	5
86	4	5	5	5	5	5–1	5	4	5	4	5	5	5	5	4	5	5–1	5
96	6	5	5	5	5	6	5	6	5	6	5	5	5	5	6	5	6	5
104	5	6	6	6	6	6–1	6	5	6	5	6	6	6	5	6	6	6	6
120	6	7	7	7	7	6	7	6	7	6	7	7	7	7	6	7	6	7
128	7	7	7	7	7	8–1	7	7	7	7	7	7	7	7	7	8–1	7	7
†135	8	7	8	7	8	7	8	7	8	7	8	7	8	7	8	7	8	7
†135*	8–1	8	8	7	7	7	8	8–1	8	7	7	7	8	8	8–1	7	7	7
150	9	8	8	8	8	9	8	9	8	9	8	8	8	8	9	8	9	8
156	8	9	9	9	9	8	9	8	9	8	9	9	9	9	8	9	8	9
†160	9–1	9	9	9	9	9k	9	8	9	9k	9	9	9	9	8	9	9k	9
*160	9–1	9	9	9	9	9–1	9	8	9	9–1	9	9	9	9	8	9	9–1	9
168	10	9	9	9	9	10	9	10	9	10	9	9	9	9	10	9	10	9
240	14	13	13	13	13	14	13	14	13	14	13	13	13	13	14	13	14	13

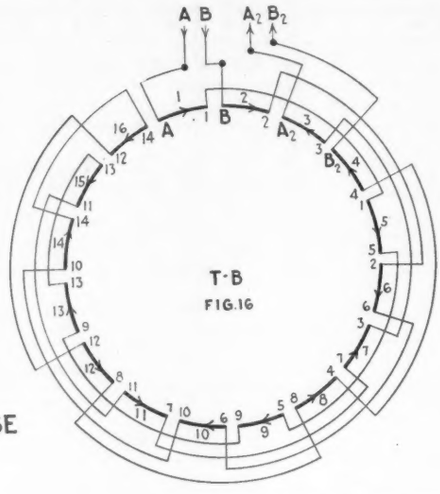
†These groupings are not for top-to-bottom connection.

kA coil is killed in each group where this symbol appears provided it appears also in the Main Table for this winding.

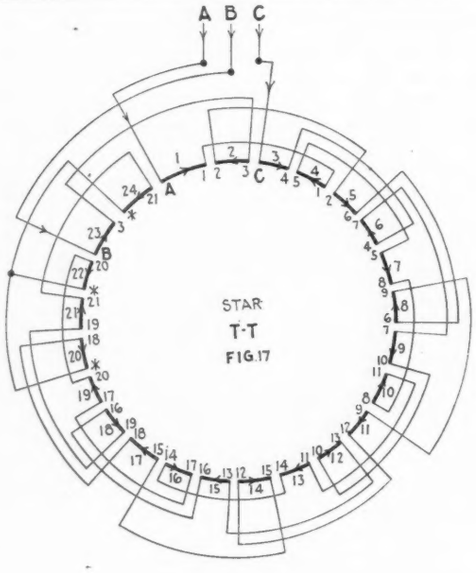
*Use this line where an asterisk (*) appears in the Main Table

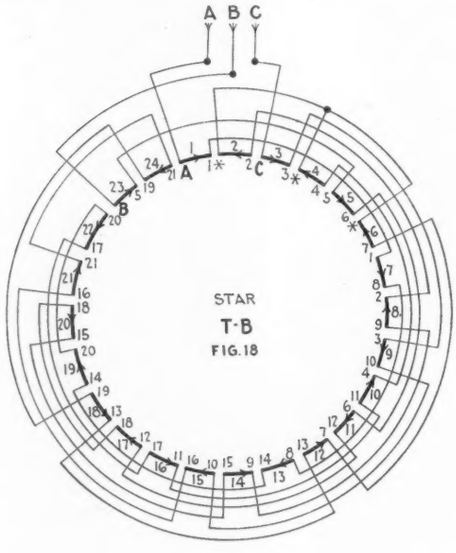
Eight-Pole Windings

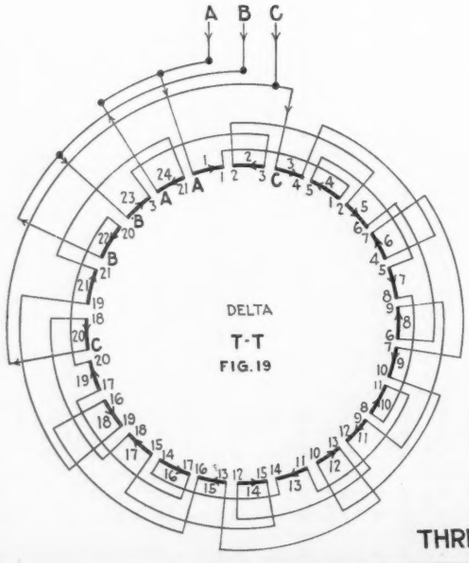


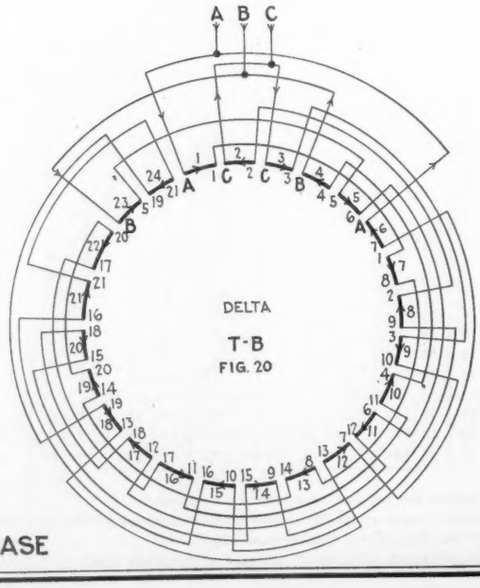


TWO-PHASE









THREE-PHASE

nected in groups of the proper number, the next step is to connect these groups together in the right relation. The diagrams and tables shown will enable a winder to make any kind of connection that is possible, either series or parallel, for two or three phases and for two to twenty-four poles.

It will be noticed that the diagrams show only the series connections for any winding. The connecting tables, however, corresponding to each one of these diagrams, tell how to make the change from the series to the parallel windings. The diagrams, it will be noticed, give both top-to-top and top-to-bottom connections for windings having two to fourteen poles. For sixteen to twenty-four poles only the top-to-top connection is given. For the three-phase machines both delta and star diagrams are shown.

How the Diagrams and Connection Tables are Used

In order to understand the use of the diagrams and connecting tables let us consider a four-pole, two-phase motor connected top-to-top. The diagram for this connection is shown in Fig. 3 and the corresponding table is shown on the page opposite this figure. In this diagram there are eight pole-phase groups represented by the eight sectors of the innermost circle. Each of these groups has a number as indicated by the figures at the center of the groups. At the beginning and the end of each group are other numbers. These indicate the numbers of the jumpers. For instance, in group 1 the figures *A* and *1* appear. This indicates that the *A* lead (one of the line leads) connects to the top of group 1. Throughout the diagrams, the top lead is the left-hand end of each group. Likewise the bottom of group 1 is connected by jumper No. 1 to another group. This happens to be group No. 3, as may be seen from the diagram.

In the connecting table, these figures which indicate the jumper numbers, are put down. As will be seen from the table the numbers for the jumpers attached to group 1 are *A* and *1*, to group 2 are *B* and *2*, to group 3 are *3* and *1* and so on. Likewise, the other connections besides the series are shown in this same table. The figures are changed only where it is necessary to change the location of jumpers on the winding.

It will be seen then, that if we have a four-pole, two-phase series motor connected top-to-top and we want to reconnect it in two-parallel top-to-top, we must make changes only where the second line in the table differs from the first line. There is no change until we reach group 3 where it is seen that the top of the group instead of connecting to jumper No. 3 as before, now connects to A_2 or the other side of the line on the *A* phase. Likewise, changes are made in the jumpers going to the top leads of groups 4, 5 and 6. The tops of these groups were originally connected to jumpers 3 and 4. Therefore, to make the change, jumpers 3 and 4 are cut in half and the top of group 3 is connected to the original A_2 lead. Likewise the top of group 4 is connected to the original B_2 lead. The other end of No. 3 jumper, which is attached to the top of group 5, is connected to the *A* lead, and the remaining end of No. 4 jumper, which is connected to the top of group 6, is now connected to the *B* lead.

Thus the table shows at a glance where a change has to be made when reconnecting.

When using the tables to connect a rewound motor a set of tags should be used. These tags are numbered according to the connections required by the connecting table. For instance, for a two-parallel, four-pole, 2-phase, top-to-top connection there would be two tags each for the following figures and letters: A_2, *A*, B_2, *B*, *1*, *2*, *5*, and *6*. After these tags are made they may be put on in the following manner. Face the connection end of the stator and call the left-hand lead of a stubbed-up group the top lead of group No. 1.

Eight-Pole Two-Phase Windings

UNEQUAL COIL GROUPING

Top-to-Top. Chart G

Coils	Group Numbers															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
24	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	2
36	3[k]	2	2	2	2	3[k]	2	2	3[k]	2	2	2	2	3[k]	2	2
54	4[k]	3	4–1	3	3	4[k]	3	3	4[k]	3	3	4–1	3	4[k]	3	3
60	3	4[k]	4	4	4[k]	3	4	4	3	4[k]	4	4	4[k]	3	4	4
62	3	4[k]	4	4	4[k]	4–1	4	4	4–1	4[k]	4	4	4[k]	3	4	4
72	4	4	5	5	4	4	5	5	4	4	5	5	4	4	5	5
84	6[k]	5	5	5	5	6[k]	5	5	6[k]	5	5	5	5	6[k]	5	5
86	6[k]	5	6–1	5	5	6[k]	5	5	6[k]	5	5	6–1	5	6[k]	5	5
90	6–1	5	6	6	5	5	6	6	5	6–1	6	6	5	5	6	6
104	6	6	7	7	6	6	7	7	6	6	7	7	6	6	7	7
108	6	7[k]	7	7	7[k]	6	7	7	6	7[k]	7	7	7[k]	6	7	7
120	7	7	8	8	7	7	8	8	7	7	8	8	7	7	8	8
135	9[k]	8	8	8	9–1	9[k]	8	8	9[k]	9–1	8	8	9–1	9[k]	8	8
150	10[k]	9	10–1	9	9	10[k]	9	9	10[k]	9	9	10–1	9	10[k]	9	9
156	9	10[k]	10	10	10[k]	9	10	10	9	10[k]	10	10	10[k]	9	10	10
168	10	10	11	11	10	10	11	11	10	10	11	11	10	10	11	11
180	12[k]	11	11	11	11	12[k]	11	11	12[k]	11	11	11	11	12[k]	11	11
216	14	14	13	13	14	14	13	13	14	14	13	13	14	14	13	13

[k] A coil is killed in each group where this symbol appears provided it appears also in the Main Table for this winding.

CONNECTIONS FOR ENDS OF GROUPS

Connect together group ends having same number or letter. Line leads are indicated by letters. A star connection is shown by (*).

Top-to-Top. See Fig. 15.

Group No.	1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16	
	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B
Series	A	1	B	2	3	1	4	2	3	5	4	6	7	5	8	6	7	9	8	10	11	9	12	10	11	13	12	14	A_2	13	B_2	14
2 Parallel	A	1	B	2	3	1	4	2	3	5	4	6	A_2	5	B_2	6	A	9	B	10	11	9	12	10	11	13	12	14	A_2	13	B_2	14
4 Parallel	A	1	B	2	A_2	1	B_2	2	A	5	B	6	A_2	5	B_2	6	A	9	B	10	A_2	9	B_2	10	A	13	B	14	A_2	13	B_2	14
8 Parallel	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2	A_2	A	B_2	B

Top-to-Bottom. See Fig. 16.

Series	A	1	B	2	A_2	3	B_2	4	1	5	2	6	3	7	4	8	5	9	6	10	7	11	8	12	9	13	10	14	11	13	12	14
2 Parallel	A	1	B	2	A_2	3	B_2	4	1	5	2	6	3	7	4	8	5	9	6	10	7	11	8	12	9	A_2	10	B_2	11	A	12	B
4 Parallel	A	1	B	2	A_2	3	B_2	4	1	A_2	2	B_2	3	A	4	B	A	9	B	10	A_2	11	B_2	12	9	A_2	10	B_2	11	A	12	B
8 Parallel	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2	A_2	A	B_2	B

On this lead put an *A* tag. Then on the bottom or right-hand lead of the same group put a No. 1 tag. The next group to the right is called No. 2 and on this group are placed the *B* tag and the *2* tag. Then follow this out according to the figures and letters in the connecting table. After all these tags are on, then put jumpers between the group ends which have similar numbers, the two tags which have No. 1 on them, the two tags which have No. 2 on them, etc. Connect all the tags with *A* to one line lead and with A_2 to the other line in the same phase. Likewise connect the B phase to the tags which have *B* and B_2.

When using the top-to-bottom connections the same scheme is carried out. In changing from series to two-parallel the short jumper is cut.

By Following the Tables it Is Easy to Change from a Star to a Delta Connection

If it is desired to change from a star to a delta connection or the reverse, simply follow the tables. As an example, on the series star connection for a four-pole motor, connected top-to-bottom, a star (*) is shown for the top lead in groups 2, 4 and 6. (*Continued on page 152.*)

Eight-Pole Three-Phase Windings

UNEQUAL COIL GROUPING—CHART H

Top-to-Top

Coils	Group Numbers																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
36	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1
54	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2
60	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2
62	3	3–1	3	2	3	2	3	2	3	2	3	3–1	3	2	3	2	3	2	3	2	3	2	3	2
80	4	3	3	3	4	3	3	3	4	4–1	3	3	4	3	3	4	3	3	3	4	3	3	4	3
84	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3
86	4	4–1	4	3	4	3	4	3	4	3	4	4–1	4	3	4	3	4	3	4	3	4	3	4	3
90	3	4	4^k	5	3	4	4^k	4	3	4	4^k	4	3	4	4^k	4	3	4	4^k	4	3	4	4^k	4
104	5^k	4	4	4	5^k	4	4	4	5^k	4	5–1	4	5^k	4	4	4	5^k	4	4	4	5^k	4	4	5–1
108	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4
128	6^k	5	5	5	6^k	5	5	5	6^k	5	6–1	5	6^k	5	5	5	6^k	5	5	5	6^k	5	5	6–1
135	6	6–1	6	5	6	5	6	5	6	6–1	6	5	6	5	6	5	6	6–1	6	5	6	5	6	6–1
150	7^k	6	6	6	7^k	6	6	6	7^k	6	6	6	7^k	6	6	6	7^k	6	6	6	7^k	6	6	6
156	7	6	7	6	7	6	7	6	7	6	7	6	7	6	7	6	7	6	7	6	7	6	7	6
160	7	7–1	7	6	7	7–1	7	6	7	7–1	7	6	7	6	7	6	7	7–1	7	6	7	6	7	6
180	8	7	8	7	8	7	8	7	8	7	8	7	8	7	8	7	8	7	8	7	8	7	8	7

Top-to-Bottom

Coils	Group Numbers																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
36	2	1	2	1	2	1	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
54	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	3	2	2	3	2	2	3	2	2
60	3	2	3	2	3	2	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3
62	3	3	1	3	2	3	2	2	3	2	3	2	3	2	3	2	3	3	3–1	3	2	3	2	3
80	4	3	3	3	4	3	3	3	4	3	3	4	3	3	4	3	3	4	3	3	4	3	3	4
84	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3
86	4	4–1	4	3	4	3	4	3	4	3	4	4–1	4	3	4	3	4	3	4	3	4	3	4	3
90	3	4^k	4	4	3	4^k	4	3	4^k	4	3	4^k	4	3	4^k	4	3	4^k	4	3	4^k	4	3	4^k
104	5^k	4	4	4	5^k	4	4	4	5^k	4	5–1	4	5^k	4	4	4	5^k	4	4	4	5^k	4	4	5–1
108	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4
128	6^k	5	5	5	6^k	5	5	5	6^k	5	6–1	5	6^k	5	5	5	6^k	5	5	5	6^k	5	5	6–1
135	6	5	6	6–1	6	5	6	5	6	6–1	6	5	6	5	6	5	6	6–1	6	5	6	5	6	6–1
150	7^k	6	6	6	7^k	6	6	6	7^k	6	6	6	7^k	6	6	6	7^k	6	6	6	7^k	6	6	6
156	7	6	7	6	7	6	7	6	7	6	7	6	7	6	7	6	7	6	7	6	7	6	7	6
160	7	7–1	7	6	7	7–1	7	6	7	7–1	7	6	7	6	7	6	7	7–1	7	6	7	6	7	6
180	8	7	8	7	8	7	8	7	8	7	8	7	8	7	8	7	8	7	8	7	8	7	8	7

[k] A coil is killed in each group where this symbol appears provided it appears also in the Main Table for this winding.

CONNECTIONS FOR ENDS OF GROUPS

Connect together group ends having same number or letter. Line leads are indicated by letters. A star connection is shown by (*).

Star, Top-to-Top. See Fig. 17.

Group No.	1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19		20		21		22		23		24	
	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B
Series	A	1	2	3	C	4	5	1	2	6	7	4	5	8	9	6	7	10	11	8	9	12	13	10	11	14	15	12	13	16	17	14	15	18	19	16	17	20	*	18	19	21	*	20	B	3	*	21
2 Parallel	A	1	2	3	C	4	5	1	2	6	7	4	5	8	*	6	7	10	*	8	B	12	*	10	A	14	15	12	C	16	17	14	15	18	19	16	17	20	*	18	19	21	*	20	B	3	*	21
4 Parallel	A	1	*	3	C	4	*	1	B	6	*	4	A	8	*	6	C	10	*	8	B	12	*	10	A	14	*	12	C	16	*	14	B	18	*	16	A	20	*	18	C	21	*	20	B	3	*	21
8 Parallel	A	*	*	B	C	*	*	A	B	*	*	C	A	*	*	B	C	*	*	A	B	*	*	C	A	*	*	B	C	*	*	A	B	*	*	C	A	*	*	B	C	*	*	A	B	*	*	C

Star, Top-to-Bottom. See Fig. 18.

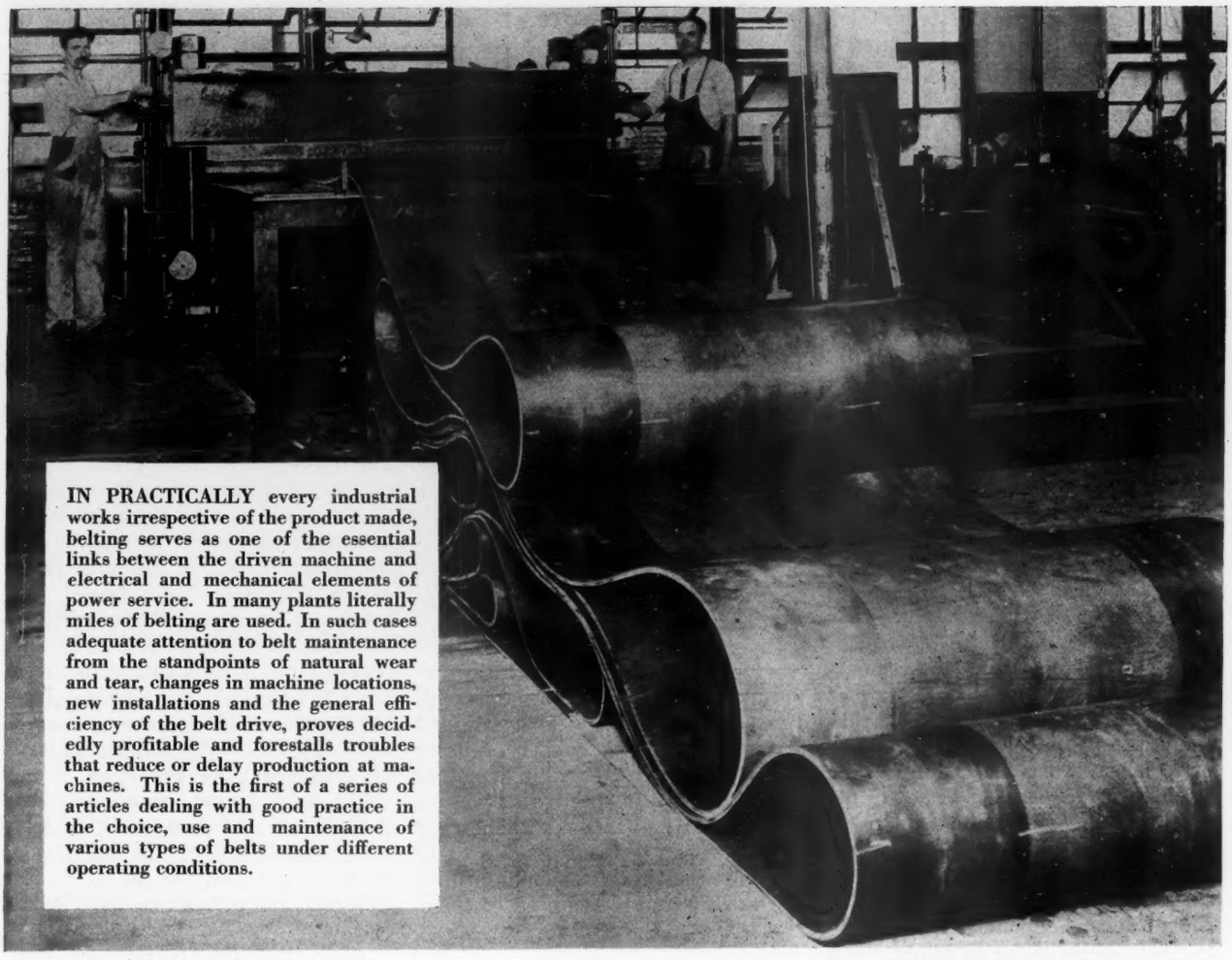
Series	A	1	*	2	C	3	*	4	5	6	*	7	1	8	2	9	3	10	4	11	6	12	7	13	8	14	9	15	10	16	11	17	12	18	13	19	14	20	15	18	16	21	17	20	B	5	19	21
2 Parallel	A	1	*	2	C	3	*	4	5	6	*	7	1	8	2	9	3	10	4	11	6	12	7	13	8	14	9	15	10	16	11	17	12	*	13	19	14	*	15	B	16	*	17	A	B	5	19	C
4 Parallel	A	1	*	2	C	3	*	4	5	*	*	7	1	*	2	B	3	*	4	A	B	12	7	C	A	14	*	15	C	16	*	17	12	*	*	19	14	*	15	B	16	*	17	A	B	5	19	C
8 Parallel	A	*	*	B	C	*	*	A	B	*	*	C	A	*	*	B	C	*	*	A	B	*	*	C	A	*	*	B	C	*	*	A	B	*	*	C	A	*	*	B	C	*	*	A	B	*	*	C

Delta, Top-to-Top. See Fig. 19.

Series	A	1	2	3	C	4	5	1	2	6	7	4	5	8	9	6	7	10	11	8	9	12	13	10	11	14	15	12	13	16	17	14	15	18	19	16	17	20	C	18	19	21	B	20	B	3	A	21
2 Parallel	A	1	2	3	C	4	5	1	2	6	7	4	5	8	C	6	7	10	B	8	B	12	A	10	A	14	15	12	C	16	17	14	15	18	19	16	17	20	C	18	19	21	B	20	B	3	A	21
4 Parallel	A	1	C	3	C	4	B	1	B	6	A	4	A	8	C	6	C	10	B	8	B	12	A	10	A	14	C	12	C	16	B	14	B	18	A	16	A	20	C	18	C	21	B	20	B	3	A	21
8 Parallel	A	B	C	B	C	A	B	A	B	C	A	C	A	B	C	B	C	A	B	A	B	C	A	C	A	B	C	B	C	A	B	A	B	C	A	C	A	B	C	B	C	A	B	A	B	C	A	C

Delta, Top-to-Bottom. See Fig. 20

Series	A	1	C	2	C	3	B	4	5	6	A	7	1	8	2	9	3	10	4	11	6	12	7	13	8	14	9	15	10	16	11	17	12	18	13	19	14	20	15	18	16	21	17	20	B	5	19	21
2 Parallel	A	1	C	2	C	3	B	4	5	6	A	7	1	8	2	9	3	10	4	11	6	12	7	13	8	14	9	15	10	16	11	17	12	C	13	19	14	B	15	B	16	A	17	A	B	5	19	C
4 Parallel	A	1	C	2	C	3	B	4	5	C	A	7	1	B	2	B	3	A	4	A	B	12	7	C	A	14	C	15	C	16	B	17	12	C	A	19	14	B	15	B	16	A	17	A	B	5	19	C
8 Parallel	A	B	C	B	C	A	B	A	B	C	A	C	A	B	C	B	C	A	B	A	B	C	A	C	A	B	C	B	C	A	B	A	B	C	A	C	A	B	C	B	C	A	B	A	B	C	A	C



IN PRACTICALLY every industrial works irrespective of the product made, belting serves as one of the essential links between the driven machine and electrical and mechanical elements of power service. In many plants literally miles of belting are used. In such cases adequate attention to belt maintenance from the standpoints of natural wear and tear, changes in machine locations, new installations and the general efficiency of the belt drive, proves decidedly profitable and forestalls troubles that reduce or delay production at machines. This is the first of a series of articles dealing with good practice in the choice, use and maintenance of various types of belts under different operating conditions.

One of the most important steps in the manufacture of a belt—the cementing of the laps and plys. This is a 60-in. three-ply main drive belt being made on an 86-in. belt press. Unless this operation is done properly a belt will soon begin to open at the laps.

Points of Construction And Other Things About

Fabric-Base and Leather Belts

On Which Good Service from the Pulley and Belt as a Unit Depend

By FRANK E. GOODING
Associate Editor, Industrial Engineer

RECENTLY a large 40-inch double leather belt was removed from service after 34 years of operation in an industrial plant on a water wheel drive that operates 24-hr. a day. Although the machine which it drove for these years was worn out, the belt was cut up and is still giving service on other machines. During this time there is no record of the belt having given any serious trouble. Who would question but that this was an economical belt installation? Doubtless many other belts just as good as this one were put on at the same time and lasted only a few years. It seems, therefore, that belt trouble is not always the fault of the belt. Much depends upon the proper choice of a belt suitable for the work it is to do. As a foundation for making the choice this article will take up the essential details of construction and operation of various types of belts. Other articles to follow will cover the selection, ordering specifications, inspection, maintenance, and reclamation of belts.

THE DIFFERENT TYPES OF BELTS

There are two general classes of belts—those made of cotton as a base and those made of leather. Belts with cotton fabric as a base are divided into three general classes: (1) Solid-woven belts; (2) canvas belts, and (3) rubber and Balata belts. Solid-woven cotton belts are woven to any required thickness as a solid belt. The various thicknesses are designated by "plys" but it is not a standardized dimension. One manufacturer, for example,

makes single, double and triple ply, solid-woven belts which it is claimed correspond to the single, double and triple leather belts.

Canvas belts are made by wrapping or folding several thicknesses of canvas and stitching them together. In some belts the stitches are covered with another layer or ply of canvas and again lightly stitched. Cotton belts, either solid-woven or stitched, are practically always impregnated with some special preparation which renders the belt waterproof and in some cases protects it from fumes, steam or other deteriorating conditions. In addition, this preparation lubricates the working parts of the belt so that the fabric is more pliable and causes less friction in the repeated bending and straightening of a belt in operation.

Rubber belts are built up by either folding or wrapping various thicknesses or plys of canvas and cementing them together with a rubber gum. An additional coating of rubber is placed on the outside and the entire belt vulcanized. Here the thicknesses of rubber between the layers of canvas take the place of the stitching, although in some cases rubber belts are also stitched. The thickness of the outer coating of rubber depends upon the work which the belt is called upon to do. For example, conveyor belts generally have a thick coating of rubber to take the wear of the material carried and also to protect the belt from dampness. Power transmission belts generally have a thin or friction coat unless they are to be used in wet places, and then the coating is heavier.

Balata belt differs from rubber belt in that Balata gum is used instead of rubber gum and that the method of preparation and arrangement of the fabric base and the impregnation with gum are different. Practically, the fabric gives the belt strength while the rubber or other impregnation cements it together and also gives it tractive as well as a good wearing surface. Rubber and canvas belts are made from 4 to 12 plys in thickness, depending upon the work which is required of them.

One of the most severe driving problems exists where there is a wide variation between the diameters of the driving and driven pulleys, as here.

Here a 9-in., double leather belt on a 10-in. motor pulley drives a 36-in. blower pulley set at 9-ft. centers. The belt travels at 2,356 ft. per min. and operates 24 hrs. per day. This belt is operated with 22 in. of slack due to the special treatment which makes it cling to the surface of the pulley and gives it sufficient adhesion without high tension.

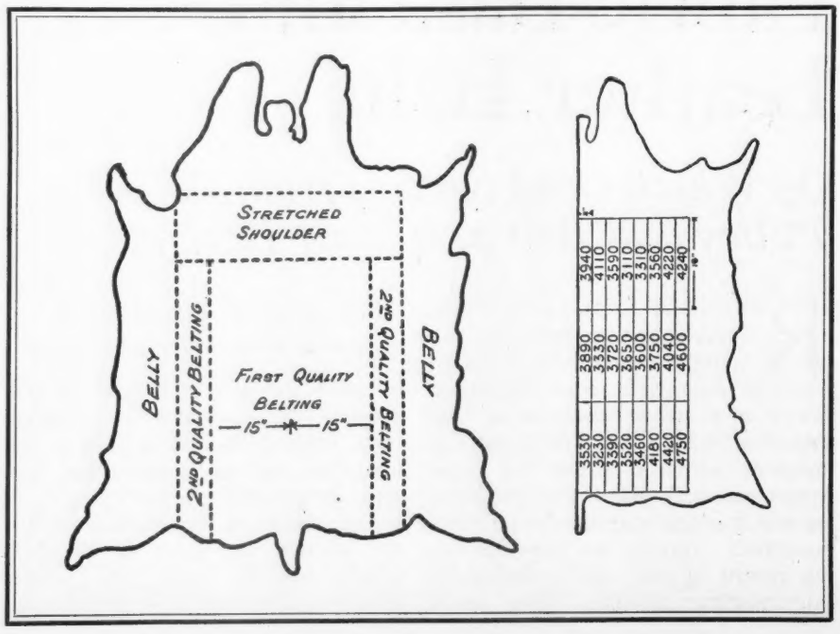
The Types of Leather Belting

Leather belts of the best quality are made from oak-tanned steer hides. Only a small portion of the hide is used in making the best belts, as shown in the accompanying drawing. This is a piece about 15 to 18 in. on each side of the backbone and from the shoulders to the base of the tail. Even this section of the hide is not uniform in all animals, as the texture of the skin varies with each individual hide, but it is the most satisfactory for making belts. Also, the strength, pliability and elasticity varies, depending upon the section of the hide from which it is cut. The tensile strength per square inch of leather cut from different sections of hides which are used for belt purposes is also shown in the smaller drawing accompanying this article.

Practically all belt manufacturers make a variety of grades of belting. The difference in these grades is due to the grading of the hide before it is cut and also to the part of the hide which is used in the belt. These various grades sell at different prices and are suitable for different purposes. Variations in the price of belts of corresponding grades purchased from different manufacturers are due to one or both of the following reasons: (1) Variation in grade of stock; (2) variation in standards of manufacturing processes.

To know what makes a good leather belt it is necessary to have some knowledge of the method of manufacture and the effect of the different production processes on the leather.

After the hide is received from the tannery the section to be used for belting is first cut out. This section then is scoured or washed. In this operation the tannery dirt and any other foreign ingredients are washed out. The hide is then ready to go to be "fleshed" where

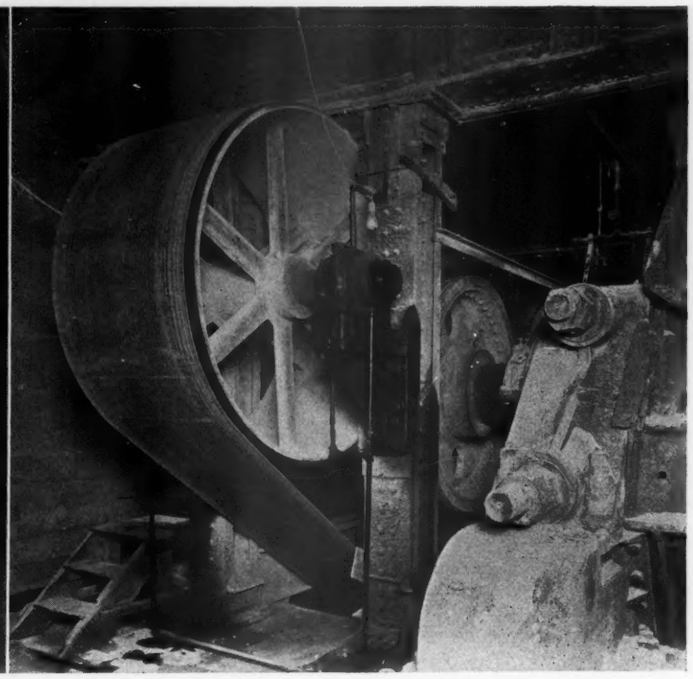


These sketches show the section of a hide which may be used for making first- and second-grade leather belts and the tensile strength of the different portions.

A section of the hide taken from a steer extending about 15 in. on each side of the backbone and about 48 in. in length is used by belt manufacturers to get first-grade belting. A narrow strip on each side is used in second-quality belting as is also a section of shoulder as indicated here. Although the portion of the hide next to the belly is the strongest, it does not make the best belts because it lacks other essential qualities requisite in good belts, as described in this article. These drawings were devised by R. E. Moore, chief engineer, Charles A. Schieren Co., New York, N. Y. Standard Government specifications state that belt must be manufactured from this section of hide.

An example of a belt-punishing drive in the cement industry.

This belt is made with two plys of leather with a ply of rawhide between. This gives it great strength with almost absolute freedom of stretch. Here it is shown driving a pulverizing machine where the belt runs quarter-turn and is sharply bent over an idler.



A heavy rubber belt on a stone crusher, another severe belt-punishing drive due to the shock loads.

any surplus or loose flesh which is left on the hide by the tanners is removed. Too much must not be shaved off as more than 60 per cent of the strength of the leather is in the inside half of the thickness.

After next passing through the "setting out" machine to smooth out the leather, it is then ready for "currying," which puts back the natural animal oils taken out in the tanning and scouring processes. This operation is of great importance in establishing the life and pliability of the belt.

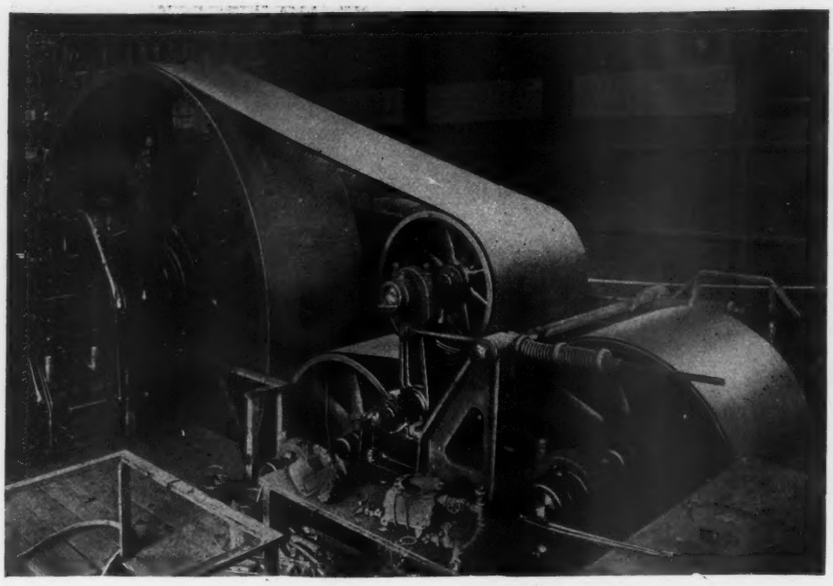
The sections of hide are then stretched until dry. Over-stretching affects the life and under-stretching causes difficulty in operation. It is now ready to be cut into strips and graded as to weight and thickness and to be joined together to make a uniform belt. The ends are next scarfed and pointed, and then cemented together under pressure. Unless the pieces are properly joined they are likely to come apart and cause trouble. Leather belts may be made waterproof by using special cement at the joints and impregnating the leather when manufactured. Leather belting ordinarily is made in single, double and triple ply. Most manufacturers make three weights of each of these: medium, regular and heavy. Single ply belting is made in all grades; double and triple ply is generally made only from the better grades of leather. One make of belt has a thickness of rawhide between two thicknesses of leather which enables it to stand up under heavy service, as rawhide is about three times as strong as leather belt and has little stretch. For light duty round- and V-belts are used extensively. Some V-belts are of solid leather while others are built up by riveting short pieces of leather together. All of these, however, are used only for comparatively light work.

Characteristics of Fabric Belts

Unimpregnated canvas belts or solid-woven belts are not used to any great extent in industry, as they will deteriorate quite rapidly if they become wet or oil soaked. When they are impregnated to withstand moisture, oil and other outside influences, care must be taken to see that they are not too heavily saturated so that they become stiff or lose their tractive effect. Manufacturers of these belts each have their own methods of impregnation and recommend that, if the belt dries out, their own belt dressing be applied.

A wide fluctuation is found among different makes of woven belt in the tractive value. Some rank very low while others rank higher when used up to their rated power. However, when they once reach the rating the tractive effort falls off quite rapidly at increased load. This characteristic is common to most all types of fabric belts. For this reason they are not used where they are subject to heavy overloading unless the capacity is increased correspondingly by using a larger belt.

Another characteristic of all belts with fabric base—this includes rubber and similar types of belts—is that stretch due to contraction of fibers comes out of the belt within the first 24 or 48 hours of service if not used at too high tension. Also during this same period the tractive value of the belt is at its highest. However, as stated before, such a wide variation exists in the quality of different types of these belts that it is difficult to make any general statement about them as a class. Those with a low coefficient of friction can be used only on machines where small power is transmitted. They are very adaptable to high-speed operation, however, and where the combination of low power and high speed exists, can be used to their best advantage. The cheaper types of these belts are frequently used around machines or other places where they quickly become soaked with oil, which spoils rubber and rapidly decreases the value of leather belting unless treated and made oil proof. When cheap fabric belts become oil soaked



This particular belt operates under severe service conditions with short sharp turns as the belt winds around the four pulleys. This illustrates one method of getting high tension and a contact of over 180 deg. on the pulleys.

and begin to deteriorate they can be thrown away as soon as they become useless for further service without any great loss. Leather belts can often be reclaimed.

Solid woven belts are frequently used as endless belts, although they must be made endless at the factory, as it is not feasible to make a joint in the shop which is smooth and gives the service which is ordinarily demanded of an endless belt. These belts are of very even texture and frequently are used to drive the spindle of internal grinders where a belt of uneven texture or with an uneven joint would affect the work. All kinds of fabric base belts are frequently used for conveyors with good success except that they cannot be used in handling hot materials or those with sharp cutting edges. Usually these belts are not recommended to be used with wet material, although, in one case, for instance, a special impregnated solid-woven conveyor belt handling a wet mixture has stood up well. Overnight the mixture would dry on the belt which had been used previously so that it was always necessary to spend an hour or two to clean up the belt. Since this solid-woven impregnated cotton belt was installed the working of the fabric, as it passes over the pulley, cracks the hardened material and in just a few moments it cleans itself. It may be worth adding that the solid-woven belts of the present day are much different from those which were brought out a few years ago. Among the disadvantages of this belt are that ordinarily a belt cannot be cut down to a narrower width, nor will it stand for continuous shifting, as on planer belts. This latter difficulty can be overcome to a large extent by using roller shifters.

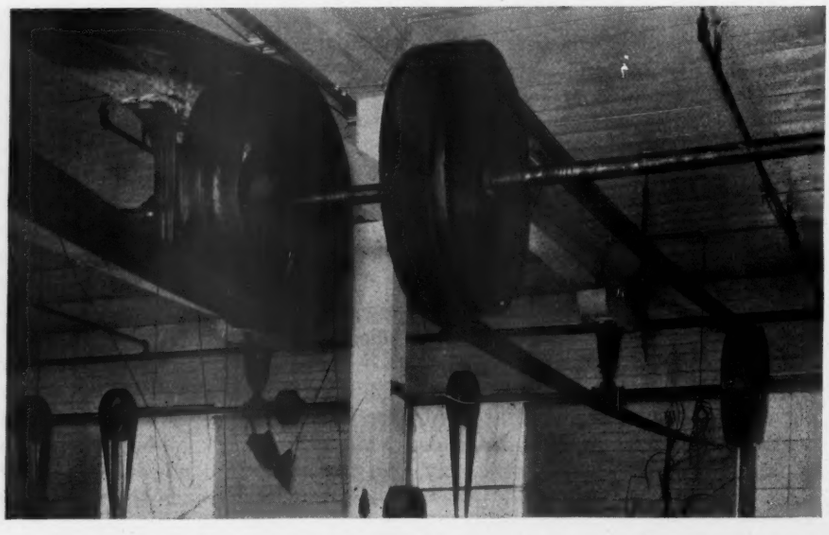
The principal advantage of stitched belts is that they are cheaper in first cost while the main disadvantage is that the stitching decreases the pliability. Many of the belt dressings that are used to impregnate stiff canvas stitched belting to render it waterproof or to give it a greater tractive value increase this stiffness. Due to its low first cost, canvas stitched belting has a wide market where the service is temporary. Like other fabric belting, this does not stand excessive shifting.

Rubber covered belting has good tractive effect up to its rated capacity but care must be taken to see that it does not slip excessively, as to do so will loosen the layer of rubber which holds the canvas plies together. Whenever air gets in between the plies or under the rubber coating, it is compressed as it passes over the pulley and often forces the plies apart for the full length of the belt, if not taken care of at once. Rubber belt withstands moisture well but it cannot be used where it is likely to come in contact with mineral oil. Also it does not work so well in extreme cold and deteriorates where it is necessary that it should stand idle for long periods, or when left lying on cement floors, a treatment which would not be recommended for any kind of belt.

There are certain definite, important qualities in leather belting which are necessary for the successful transmission of power. These are as necessary in other types of belting but are more easily pointed out in connection with leather belts, as they vary more widely in different grades of belt or under various methods of treatment. These qualities are:

1. Strength
2. Stretch
3. Pliability and texture
4. Adhesion or coefficient of friction
5. Elasticity
6. Durability
7. Serviceability

The ideal leather belt would be one in which all of these qualities are at



This belt has been operating satisfactorily for over 30 years.

This 6-in. belt drives 30-in. pulleys on 18-ft. centers at 164 r.p.m. The crossed belt at the left has been in operation for 15 years. The service record of these two belts is largely due to the treatment and care which they receive at the plant of the Agawam Co., Agawam, Mass.

A solid-woven cotton belt operating under severe conditions in a brick yard.
Thick coatings of dust as are shown here on the inside and outside of this 14-in. double belt are severe treatment for any belt. In ordering belts for dusty locations such as this an allowance is usually made for decreased adhesion due to the dust.

the highest point which it is possible to make them. However, due to the characteristics of leather, if some of these are made high others must necessarily be lower. The best belt is that which has each of these qualities developed as high as is possible without sacrificing any of the others. Belting is not made for strength alone, or for pliability alone, or for minimum stretch alone, but for the greatest strength, consistent with the minimum stretch, consistent with the maximum pliability, consistent with long life, and so on with the other qualities requisite for a good belt. The strongest part of the hide comes from the belly cut of leather, but if this were used in the manufacture of belt, both stretch and durability would be sacrificed to get strength, which is not the most essential quality for ordinary belt drives. The belly cut, although the strongest, not only stretches more than others—a factor which affects its serviceability as well as its durability, and adhesion and elasticity—but also stretches unevenly and requires more taking up of the belt. For this reason the manufacturers of the better grades of belts do not use this cut of leather for making belts. On the other hand, if too much stretch is taken out of the leather during its manufacture it will not be as strong as is desirable. All of these factors are influenced by the tanning of the leather, quality of the hide selected, and the manufacturing processes, particularly the "currying" operation where natural oils are worked back into the leather to give it flexibility and life. Even this may be overdone. However, there is use for all belts made out of the sections of the hide which is ordinarily cut up for this purpose. The belt user should be familiar with his service conditions and choose the best belt for that service. More on this phase of the subject will be given in a later article.

It is difficult to tell by observing a belt how these different qualities or characteristics are blended together in that belt. Recently the Bureau of Standards of the United States Department of Commerce, in cooperation with the Leather Belting Exchange, an association of leather belt manufacturers, prepared standard specifications for leather belting which have been adopted by the Government on belting purchases. A copy of these specifications may be obtained by addressing Louis W. Arny, secretary, The Leather Belting Exchange, 417 Forest Bldg., Philadelphia, Pa. While some of the tests mentioned are very difficult to make and require special apparatus as well as considerable skill, many of them are so simple that they may be made in a small shop. It is not to be expected that the lower grades of belting would come up to all of these specifications but they can be used to judge whether a belt is of the grade which it is claimed to be.

It is well to add a word of caution against choosing belts purely by appearance alone, as it is possible, by the treatment or working of the leather or of the materials which are worked into it, to give any appearance desired. Moreover, a high gloss has no value, except in appearance, as the gloss or polish must be worn off before the belt grips well on the pulley. This gripping of the pulley is due to the suction of the tiny vacuum cups in the surface formed by the openings in the leather where the hairs have been removed in the tanning process. For this reason the hair or smooth side of the belt should always be run next to the pulley. Tests have shown that when the flesh side of the belt is used next to the pulley the belt transmits only about 60 per cent of the power that it will when the smooth side is next to the pulley.

One important advantage of leather belts is that they can easily be made endless in any shop and if the sections of leather are well graded and matched in making up the belt, it can be used satisfactorily in the operation of such machines as wood planers, and other wood working machines which operate at high speed and are affected by an uneven joint or section of a belt.

While the best leather belts for general and most special services are made of oak tanned hides, chrome tanned leather belts are particularly useful under conditions giving a combination of high and extremely moist temperature. They are recommended wherever the temperature exceeds 150 deg. F. Also as they are extremely pliable as well as thinner than oak tanned leather they are coming into wider use for high-speed work on small pulleys. Although oak belts require six to ten months to tan in contrast to a few weeks to tan chrome leather, the latter will not displace oak tanned leather for most purposes, it does not at present have as much uniformity in quality and costs more.

There are, in addition, a few miscellaneous types of belts which do not have extensive use. One of the most common of these is what is known as camel's hair belt. This is a solid-woven belt made of camel's hair instead of cotton fabric. It has a comparatively high coefficient of friction and little slip until it reaches its rated capacity. Camel's hair belts

are more expensive than other fabric made belts, but they stand up well under severe operating conditions and are used quite commonly on drop-hammer service, where they are exposed to both heat and moisture. If they are to be made endless, it must be done at the factory as the short fiber makes splicing difficult.

Some steel belts are used, although they are not at all common. These are made of an endless flat, thin strip of steel.

In choosing any belt it should be carefully borne in mind that unless external operating conditions are such that any belt is ruined in a short time, the consideration of first cost is an insignificant item. The two main considerations in the operation of a belt are: (1) Ability to deliver the power expected of it and, (2), continuity of service without excessive attention and adjustments. A belt which slips continuously is not only wasting power but also will have a short life and be continually giving trouble. Choosing the right belt will eliminate most of the slip. It does not require a great deal of attention or lost power to more than absorb any saving in first cost of a poor belt over a good one.

The conditions under which belts operate, types of drives and practical methods of determining the proper size of belt, will be taken up in the second section of this article. Other sections will cover inspection and maintenance records and methods as well as reclamation work.

EDITOR'S NOTE: Acknowledgment is made to the following companies for assisting in furnishing information and photographs for this and the other articles which will follow in this series: Louis W. Arny, Sec., The Leather Belting Exchange, 119 S. Fourth St., Philadephia, Pa.; E. C. Atkins & Co., Indianapolis, Ind.; Victor Balata & Textile Belting Co., New York, N. Y.; The Bristol Co., Waterbury, Conn.; Chicago Belting Co., Chicago, Ill.; Cling-Surface Co., Buffalo, N. Y.; R. & J. Dick Co., Inc., Passaic, N. J.; Detroit Oak Belting Co., Detroit, Mich.; Flexible Steel Lacing Co., Chicago, Ill.; The Gandy Belting Co., Baltimore, Md.; The B. F. Goodrich Rubber Co., Akron, Ohio; The Graton & Knight Mfg. Co., Worcester, Mass.; Hide Leather & Belting Co., Indianapolis, Ind.; Imperial Belting Co., Chicago, Ill.; Jewell Belting Co., Hartford, Conn.; Laurence Belting Co., New York, N. Y.; Manheim Mfg. & Belting Co., Manheim, Pa.; New York Rubber Co., New York, N. Y.; Charles A. Schieren Co., New York, N. Y.; Stanley Belting Corp., Chicago, Ill.; The Strong Rubber & Asbestos Mfg. Co., New York, N. Y.; United States Rubber Co., New York, N. Y.; I. B. Williams & Sons, Dover, N. H.

Connecting Induction Motors

(*Continued from page 146.*)

In the table for the delta connections a *C* is shown for the top connection in group 2. For the top connection in group 4 is a *B* and for the top connection in group 6 is *A*. These are the only places in which the series delta connection differs from the series star connection. Then to change the connection from series star to series delta, we connect the top of group 6 to an *A* lead, the top of group 2 to a *C* lead, and the top of group 4 to a *B* lead. This can be done by cutting open the star leads at the star point and splicing on enough wire to make the connections to the proper leads.

These diagrams and connection tables can be used with either a long or short type of jumper regardless of how the leads, stars, etc., are brought out and independently of the direction in which the winding proceeds. For example, suppose we have a six-pole series star-connected motor with top-to-top jumpers which we want to change to two-parallel star. First we consult the table for six-pole three-phase star with top-to-top connections. Finding the *Two-Parallel* line in this table, we start at any lead and pass through three groups. The end of the third group will be a star point, and the beginning of the fourth group will be a line lead. Therefore, it is necessary only to take any lead to start with and checking through three groups cut the jumper between the third and the fourth groups. Bend the end of the jumper attached to the third group in towards the center of the stator, then with a piece of string or tie wire, tie the other part of the jumper to the original lead upon which we started. This ties the original lead to the beginning of the fourth group. After this is done for one phase, repeat the same process for the other two phases. Then connect together the three leads which have been bent in towards the middle and these will form the second star connection. It is not necessary to connect both of these star points together. To complete the operation the line leads are then attached to the other halves of the jumpers to which they were tied by the tie wires or strings.

This method can be applied to any connection. It would be time well spent to follow each connection in the tables and see where and how the break is made from one connection to another.

A delta connection is the one that is likely to trip the beginner, therefore a few more words upon it may be valuable. Suppose that we have a two-parallel delta six-pole top-to-top connection and we want to reconnect it to series delta. In the two-parallel connection each line lead will have four taps connected to it, two top jumpers and two bottom jumpers. For the purpose of this discussion we may consider that all the top leads are incoming leads. The bottom leads could be chosen if desired, but in this case we shall take the top leads. If the top leads are chosen they must be kept as incoming jumpers throughout the job. Considering the top leads as the incoming leads take any one line and cut off the bottom leads attached to it. Do likewise to the remaining two line leads. After this is done there will be six bottom leads projecting from six groups. Then take the first bottom lead to the right and calling this group No. 1 count over to group No. 4. Join these two groups together. This will leave four leads. Take the next group to the right and calling this No. 1 count over to group No. 4 and connect the bottom leads of these two groups together. The remaining two leads are then connected together. To check the connections start at any one line lead and follow the winding through each phase. Then if the connection is correct the three phases will have been passed through and the end of the operation will bring us to the line lead upon which the start was made.

The following general rules for reconnecting three-phase motors should be remembered. Pole-phase groups 1 and 4 apart belong to the same phase but are of opposite polarity. If we enter group No. 1 on a top lead we must enter group No. 4 on a bottom lead. Likewise pole-phase groups 1 and 7 apart belong to the same phase and have the same polarity. In this case if we enter group No. 1 on a top lead we must enter group No. 7 on a top lead.

In the next issue of INDUSTRIAL ENGINEER this article will be continued. If any reader finds it hard to follow the points discussed, I shall welcome a letter referring to his particular difficulty which will be cleared up in the articles that follow.

THIS IS THE THIRD of a series of articles by Mr. Martindale started in the October, 1922, issue. The first article dealt with troubles arising from the wrong grade of brush and the second, which appeared in the December issue, took up troubles due to faulty brush operation. Two more articles are to follow: One will deal with troubles caused by armature and field defects and the other with troubles from sources external to the machine.

Some of the Ways

Defects In a Commutator

Show Up as Troubles At the Brushes or Poor Condition of the Commutator

By E. H. MARTINDALE

President, The Martindale Electric Company, Cleveland, Ohio

The operator in this illustration is removing ridges and flat spots on the commutator by the use of a commutator stone moved back and forth across the face of the copper while the machine is in operation.

THIS article follows the outline of Section III of the double-page chart showing brush and commutator troubles that appeared with the first article of this series by the writer on pages 476 and 477 of the October, 1922, issue of INDUSTRIAL ENGINEER.

1. *Brush Studs Not Parallel to Commutator Bars.* — This trouble might have been treated in the previous article as due to faulty brush operation since the trouble is sometimes due to crooked brush studs, but in other cases, especially on small commutators, it is due to a twisted commutator. In either case the effects are quite similar to those treated under "Brushes too thick" in the article by the writer that appeared in the December, 1922, issue of INDUSTRIAL ENGINEER. These effects are caused by the brushes spanning too many bars. The path of the short-circuit current, however, instead of being under the face of each brush is from one brush up through the brush stud and down through another brush on the same stud. This, therefore, adds the danger of loosening brush shunts as the short-circuit current passes through them.

2. *High Mica.*—High mica may be caused by sparking that burns away the copper leaving the mica higher than the bars and by several other defects as checked on the chart that appeared in the October, 1922, issue already referred to. The direct effects of high mica are to prevent the brushes from making proper contact with the surface of the commutator.

It is now very general practice to undercut mica even when commutators are operated in dirty locations. During the past few years the "V" shaped slot has grown rapidly in favor for two reasons. First, it will not collect dirt, and second, this shape of slot automatically prevents leaving thin strips of mica along the edges of the bars which is a frequent result when slotting saws, hack-saw blades or other devices are used to cut a "U" shaped slot between the bars.

When a machine operates in a very dirty location an added precaution is sometimes taken of coating the slots with an air-drying, oil-proof, insulating varnish. The varnish should be one that will dry glass hard and that may be stoned or sanded from the face of the commutator without peeling loose from the edges of the slots. The varnish should further be able to withstand sparking and heating without decomposition or softening.

The best way to prevent all of the troubles shown under high mica is to either keep the mica undercut *properly* or keep it stoned down even

with the bars. It requires more pressure to grind copper than mica and the claim has been made by some operators that the particles of abrasive rolling under a commutator stone will cut deeper into the mica and keep it very slightly below the surface of the bars of the commutator.

3. *High Bar.*—A high commutator bar will usually cause a flat spot directly back of it whether or not the mica is undercut. This is because the high bar lifts the brush from the commutator and the latter travels several bars before the brush gets back to a good contact. If you have a flat spot on a commutator, examine carefully the bar just ahead of it. If the bar is high it will usually be brighter than the average because of the high brush pressure on that bar when it lifts the brush thereby applying the total brush pressure to a single bar.

The best remedy for a high bar is to tighten the commutator bolts while the commutator is hot and then grind the commutator while it is running at full speed.

If all of the bars are not equally gripped by the V-ring, some of them may be slightly loose. A turning tool has a tendency to push those bars in and then when the commutator is brought up to full speed, the centrifugal force throws the loose bars out, making them higher than the others.

Grinding at operating speed prevents this shifting of the bars.

4. *Low Bar.*—The most frequent cause of a low bar is the dropping of a heavy tool or other article onto the commutator and thus driving one of the bars in. It is sometimes caused by the spring in a turning tool particularly when some of the commutator bars are softer than others, permitting the tool to dig deeper into the soft bars. The spring of the turning tool may not be more than two or three ten-thousandths

Fig. 1—These are single end and double end commutator slotting files that are used when making a V shaped slot in the commutator.

Fig. 2—When using this motor-driven slotter, the slotting tool is clamped onto the armature shaft and driven by a flexible shaft connection.

Fig. 3 — Portable hand-operated commutator slotter driven by a motor through a flexible shaft.

Fig. 4—Motor driven commutator slotter for use in the repair shop.

Fig. 5 — The upper illustration shows a portable slotter driven by compressed air. The lower illustration is another portable design driven by a motor through a flexible shaft.

Fig. 6—This hand-operated, motor-driven slotter makes use of a small saw the width of the slot that is to be cut between bars.

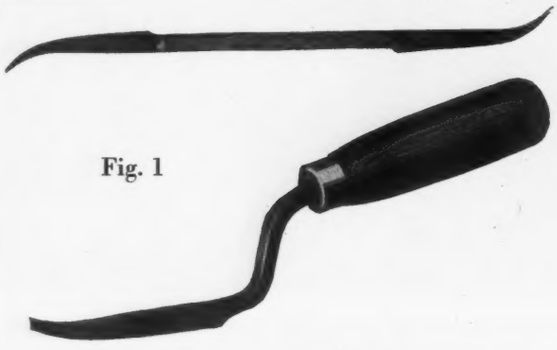


Fig. 1

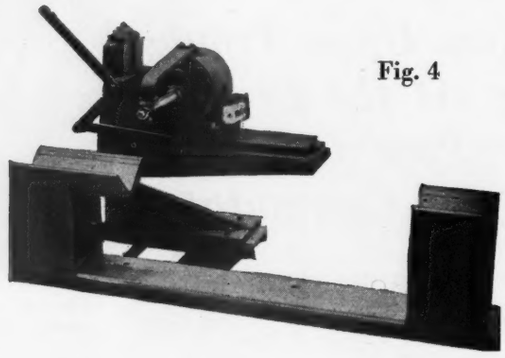


Fig. 4

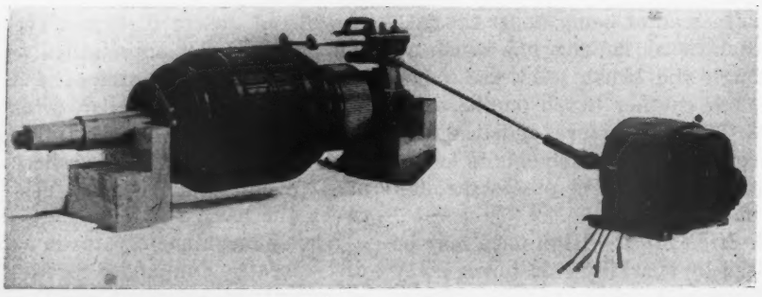


Fig. 2

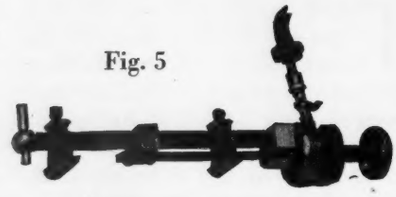


Fig. 5

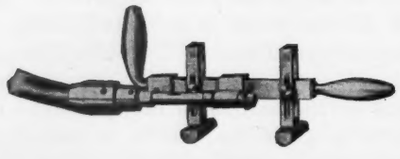


Fig. 3

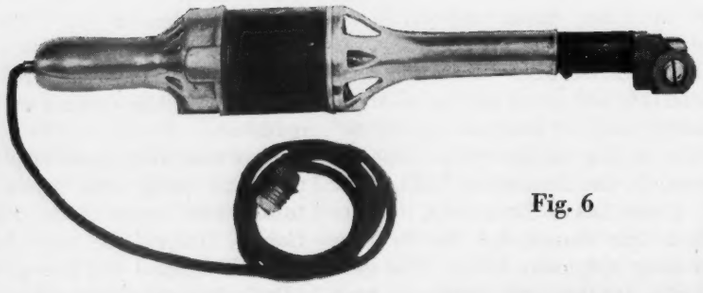


Fig. 6

of an inch, but this is sufficient to prevent proper contact between the brushes and the low bars.

A low bar will practically always start a flat spot. When a flat spot once starts it will grow very rapidly because of the severe sparking every time it passes under a brush.

A flat spot at one point on a commutator very often starts other flat spots equally spaced around the commutator corresponding to one-half the number of poles. Thus, a six-pole machine will show three flat spots 120 degrees apart and an eight-pole machine four flat spots 90 degrees apart. This is caused by the temporary interruption of current at the original flat spot throwing an extra load on the other studs of the same polarity. Most large industrial works have a well-organized fire department because a minute saved may mean a building saved. Give a flat spot the same prompt attention. Every time the spot passes under a brush the fire is burning deeper into it. When the spot is one bar wide it may be stoned out entirely in a few minutes with the loss of a very few thousandths of an inch from your commutator. Don't use sandpaper because it is too flexible even when used on a wooden block and will only clean up the spot without entirely removing it. Delay may necessitate the removal of an eighth of an inch of perfectly good commutator to remove one neglected flat spot.

5. *Eccentric Commutator at High Speed.*—As long as the speed of the commutator is low enough to permit the brush to follow the movement of the commutator, eccentricity is not serious, but as soon as the speed becomes high enough to tend to throw the brush from the commutator it will cause a low brush pressure just behind the high spot of the commutator and will start a flat spot at that point.

Where much eccentricity is present hand commutator stones are not recommended. The commutator should either be turned with a tool or ground with a stone held in a rigid support.

6. *Rough Commutator.*—A rough commutator may be caused by flashovers or by the use of coarse sandpaper. While a rough commutator may cause some sparking due to poor contact between the brushes and the commutator, its main effects are commutator heating due to increased friction and rapid brush wear that is caused by the rough surface. (*Continued on page 171.*)

Four Armature Slotting Tools for the Repair Shop

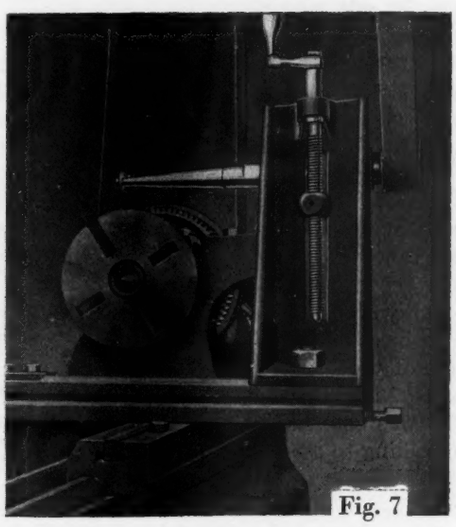


Fig. 7

Fig. 7—This design of commutator slotter is made for mounting on a lathe.

Fig. 8—This is a portable type of repair shop commutator slotter that can be used with armatures of various sizes.

Fig. 9—This is a portable type of motor driven slotter for use on large commutators.

Fig. 10—This illustration shows how an ordinary shaper can be used to slot a commutator when fitted with the proper shape of tool.

Fig. 9

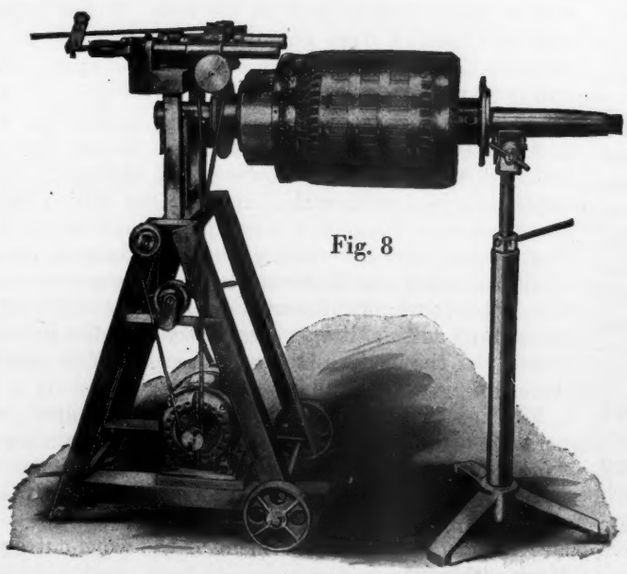


Fig. 8

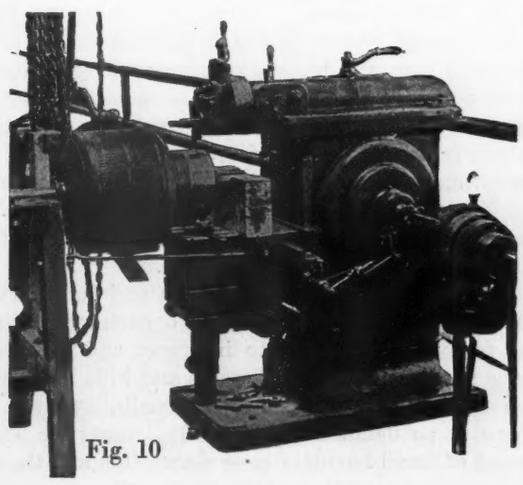


Fig. 10

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

DANIEL H. BRAYMER
Editorial Director

Assisted by

G. A. VAN BRUNT E. H. HUBERT F. E. GOODING

Chicago, March, 1923

Is Your Job Running You?

EVERY executive on whom directors and stockholders place the responsibility for success or failure of the operations of business pays most of his attention to plans of the future and day-to-day results as they show up in production data and financial statements. He must depend upon an organization for initiative and ability to assume a responsibility for working out the details of his plans and seeing that these details are properly executed. But as you go down the line in an organization there is evidence in spots and places of men who have initiative and a willingness to assume responsibility but fail to get results largely because they are not running their job —their job is running them. And in these cases one of two reasons can be found for the condition. The management lays its plans well and details the work but fails to designate responsibility for these details and indicate the day-to-day checks that will be used to measure the results. In such cases errors of judgment and lax methods come to the top of the table only after long periods and valuable time is spent in correcting conditions that should be spent in following through on the original plans.

The second reason is found in a tendency to throw around a man and his work such overlapping divisions of responsibility that his time is spent in conferences with his associates and he is continually reporting on details to others who are directly interested only in the execution of their own plans. Under such conditions the time of such a man is taken from the details of his own responsibility and the job runs him in every sense and the results he secures show it.

Between the head of a business and the foreman in charge of production too many department heads and too many opportunities to interpret and give instructions spells confusion and waste and kills initiative and the willingness to assume responsibility over which there is no definite and individual control. The successes of small business have shown this and the wastes in large organizations have proven it.

Every job should be analyzed from the bottom upward, not from the top downward. Take the repair shop of an industrial works for example. The extent of repairs and general upkeep depends upon the extent of the equipment operated and the productive life that this equipment is known to possess. If output is held up by frequent failures, the causes cannot be located in discussions among executives. The production methods and the machines must be examined and watched by those who are in direct charge. Then the recommendations that result must be acted upon and the remedies applied. An executive discussion on the production sheet of a machine bay that does not show, say, seven failures of a crane motor in a week and the superintendent is not provided with a detailed report of these failures and there is no way to show these in terms of lost-time delays on the production sheet, is just a talk-fest on generalities.

If your job is running you and you are constantly checking up on things you did not expect to happen and you know how they can be prevented, it's time to stop and climb up on top of that job even if it takes a little overtime thinking and a heart-to-heart talk with the boss. If he doesn't get the point, it's time for you to look around for one who will.

When Maintenance Costs Are the Key to Replacements

INSPECTION and maintenance are usually neglected rather than overdone. But some old equipment requires so much time in inspection and so many repairs that the expense of keeping it in operation is not warranted. In such a case it is self evident that the money spent in putting in new equipment to replace the old will often earn a dividend that will interest any business man who studies investments from the standpoint of the dividend yielded.

The wisdom of replacing equipment that has served its useful life, was emphasized by a steel-mill engineer recently. In talking to a section meeting of the American Institute of Engineers this engineer said:

"A number of our old mill-type motors repeatedly got into trouble. Grounded coils and commutators as well as short circuits kept us worried. A few modern mill-type motors were bought to replace some of the old ones. The result was to cut the repairs and shutdowns 90 per cent. Of course the biggest gain we made by this change was in reducing the number of shut downs. These are worth a great deal in lost time and production. In addition, however, the saving in repair expenses was considerable. In fact, the saving on repairs per year equalled a large percentage of the first cost of the motors. Where the maintenance on the obsolete motors cost $1.50 per horsepower per year, the new motors cost only 15 cents or one-tenth! With such a percentage as this, it was easy to see that the purchase of more of the modern motors was a profitable expense. Accordingly we have purchased them."

The thought summed up is this: It is good business to spend enough money in organized maintenance work to know how much it costs to keep equipment in good operating condition. It is poor business to keep on spending money in this way when a part of it can be reclaimed by the replacement of the worn-out equipment with new.

Concerning the Kind Word

SINCE the first issue of INDUSTRIAL ENGINEER appeared under that name and its present editorial scope, now 14 months ago, we have received more than 1,000 letters from readers commenting on articles that have appeared and furnishing suggestions for other articles and requests for specific information for which they find a need. These letters have taken advantage of our repeated assurance that such suggestions from readers will be carried out in every instance where the request is possible and practicable and that the paper is edited for men responsible for works operating and maintenance problems by the men who are studying these problems and have worked out particular phases of them. Although it is not always possible to answer in detail all of the letters received, we take this opportunity to say that none has been overlooked and that in due time the paper itself will answer through the material published the points which have been brought up.

These letters have revealed to us three definite things about our readers. First and most important, they are thinkers and doers—men who take their jobs seriously and find time to read and digest information that will broaden their experience and help them to do the same job better the next time it comes up.

Second, they read the advertisements in INDUSTRIAL ENGINEER as well as the text pages, for the letters we have received contain such remarks as:

1. INDUSTRIAL ENGINEER is simply fine. I enjoy reading everything in it, and get something of value from every department—even the ads. 2. In all the various departments I find something worth while. I get things that I can use in my work or add to my stock of knowledge on most every page, even the advertising section. I'd hate to miss a copy. 3. INDUSTRIAL ENGINEER is the best magazine for the practical man that is published. I find it very interesting and useful from cover to cover. 4. The data I have secured I have never seen published before and I have been in maintenance work for 21 years. If through fire or otherwise I should lose my past issues I would consider the loss irreparable. No insurance could replace them or make up the loss. 5. The first issue I have received contained an article that I have referred to more times than any other book that I own. It is within hand reach all of the time. 6. Enclosed is my renewal for two years more. I think my subscription runs out in March and I don't want to miss a copy. INDUSTRIAL ENGINEER is the most practical magazine I have been able to get and I have tried them all. 7. I can fairly see INDUSTRIAL ENGINEER grow from month to month. Your articles which get at the root of certain troubles in connection with maintenance work are always helpful. Ideas as to how other plants carry on are always in order. 8. The editorial policy as outlined in the past year is one of which you may be very proud as it is liberal enough to satisfy the technical as well as the practical man. During the past 10 years it has been my lot to operate plants which had to be kept from the scrap pile with the very smallest possible expenditure for new apparatus—hence any articles which describe equipment and its uses are doubly welcome to me, etc., etc.

Failure to read the statements made by the manufacturers concerning their equipment made for industrial use in a paper such as INDUSTRIAL ENGINEER is certain to mean that a lot of useful information is being overlooked. When it is realized that manufacturers devote a great deal of time to the preparation of their statements and use every known scheme of the advertising art to call attention to the fact that they stand ready to furnish at no cost practically any information that may be asked for concerning their equipment, a careful reading of their statements will often point the way to securing particular information that you have been looking for. Bulletins on equipment are a particularly good source of information for men who frequently have to take down and overhaul industrial equipment. In fact, an up-to-date file of worthy bulletins, worthy because they contain useful information besides generalities, is a valuable treasure in books if you know when and how to use them. This is the reason INDUSTRIAL ENGINEER carries in each issue a department devoted to "Trade Literature You Should Know About."

The third thing embodied in the letters received is a cordial and free expression of appreciation for assistance furnished through articles that have appeared. Naturally this is keenly appreciated by the editors, but whatever of credit is due in this connection must be returned to the contributors and the readers who are working with the editors and furnishing helpful suggestions, results of experiences and other practical assistance that will carry out to the fullest degree the statement of one reader when he said: "I expect you think it has taken a long time to tell you what I think of your paper or rather *our paper*, since you say it is built on the thinking of its subscribers." In this connection we recall the story of a certain American who was visiting London and gave a waiter the following breakfast order: "Two boiled eggs please, some toast, coffee and a kind word." The waiter brought the order and started to leave in silence. Whereupon the American asked, "How about the kind word?" The waiter then bent over and whispered, "Don't eat the eggs!" We, too, as editors want our readers to take us literally and furnish the kind word in suggestions, constructive comments and requests for information that you need whenever and as often as the spirit moves you.

Big Enough to Be Small

LAST month there were two red numbers on the calendar—February 12 and 22. What did they mean to you besides a holiday? To help you answer this question in case it comes up again, these two incidents printed in a recent number of the house organ published by the Hygrade Lamp Company of Salem, Mass., furnish a sharp-pointed suggestion:

"What are you crying about?" asked a man of a twelve-year old girl standing by a gate on a street of Springfield, Illinois.

"The drayman hasn't come for my trunk and I shall miss the train."

"Dry your tears, sis, I reckon we can fix that." Up went the trunk on this strong man's back and off they went to the station in time for the train.

That man was Abraham Lincoln. Big enough to be small.

* * * *

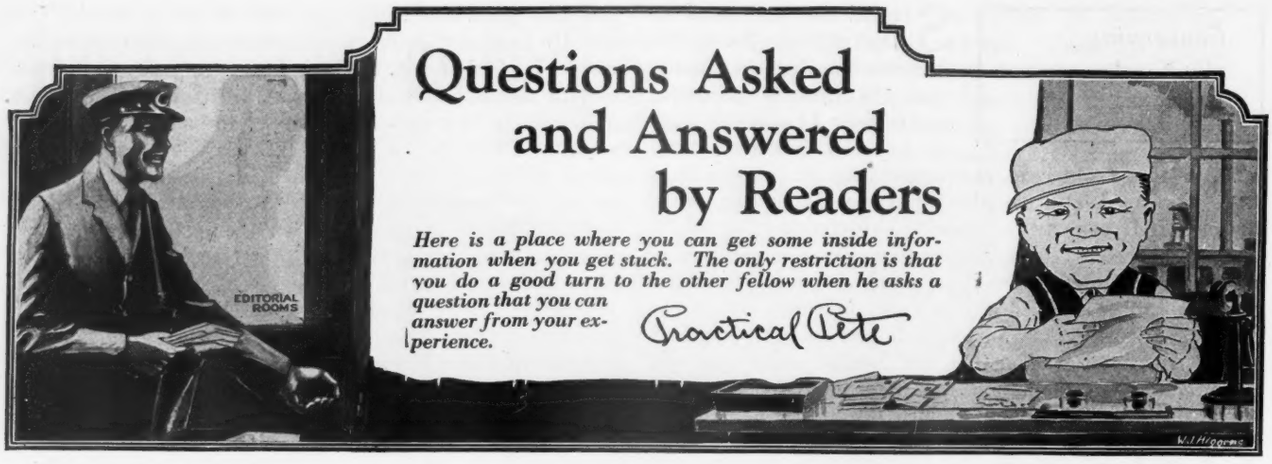
"Heave away there! Yo heave!" A corporal was giving orders to a squad trying to move a timber. But the timber was too heavy.

Presently a man rode up on a horse and inquired: "Why don't you help them?" "Not I; I'm a Corporal."

The man dismounted and lined up with the soldiers. "Now, all together—Yo heave!" When the timber went into place, the man turned to the corporal and said: "Next time you have a timber too large for your men to move, just send for your Commander-in-chief."

That man was George Washington. Big enough to be small.

By observing the results accomplished by men who are big enough to be small, many of the secrets of success in all work can be discovered. In this connection we quote Abraham Lincoln again, "If you intend to go to work, there is no place better than where you are. If you do not intend to go to work, you can't get along anywhere."


EDITORIAL ROOMS
Questions Asked and Answered by Readers
Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.
Practical Pete
W.I. Higgins

Who Can Answer These?

Elimination of Arc Lamp Noises—Will some reader please tell me how I can overcome the noise in a. c. arc lamps.
Bridgeport, Conn. G. R. C.

* * * *

How to Figure Ampere Rating of a Cable—How can I find the rating of a cable when I know the number of wires in the cable and the size of these wires? For instance, what is the rating of a cable that is made up of seven No. 14 wires?
Sartell, Minn. L. S.

* * * *

Flexible Cord and Reel for Coal Loader—I would like to get some two-wire flexible conductor for an outdoor coal loader. Also some kind of a reel that will keep up the slack as the loader is moved from one place to another. Would some of your subscribers please state what they find to be the most serviceable material and reel for this work?
Norwich, Conn. G. E. G.

* * * *

Trouble With Sparking at Brushes—Will you please answer the following and explain what the trouble is? We have a 500-kw. rotary converter which has for some time been giving trouble from sparking. The commutator has been turned down and slotted and still it is sparking. The spark is a light blue, leaving the brush on the leading side. It does not burn the commutator and acts like a static spark. It is not quite so bad when running with the compound switch in.

We have been over the field connections and everything else we could think of that would cause it to act this way. What do you think the trouble comes from?
Natick, Mass. J. A. P.

* * * *

Rewinding Motor for Four Speeds—We have a 5-hp., 1800 r.p.m., 220-volt, 3-phase, 60-cycle induction motor which has 48 slots in stator and is wound with 24 coils made of 13 turns of No. 15 wire. This motor is now connected single star. There is room in the stator for another winding due to there now being only one coil in each slot. There are 55 bars in the rotor. Short circuiting rings are ½ in. square, laminations 3¾ in. wide.

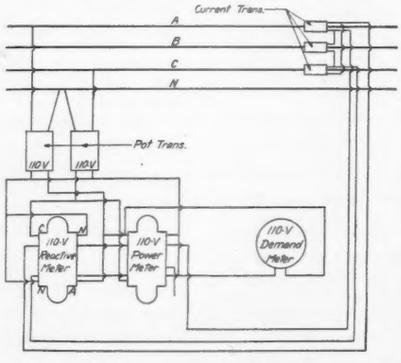
We would like to know if it is possible to rewind this motor with two sets of winding and secure four speeds: 600, 900, 1200 and 1800. The horsepower required at slow speed is about one.
Logan, W. Va. B. S.

* * * *

Location of Starting Equipment for Synchronous Motor—We are about to install a 350-hp. synchronous motor on a circulating pump. Would it be practicable to install the starting equipment about 100 ft. from the motor at the main switchboard, although the man starting the motor would not be able to see it? However, a man standing about 25 ft. from the motor could easily signal the operator. The main switchboard is on a gallery above the motor and if possible we would like to have the switchboard operator handle the starting and stopping of the pump.
Hudson, N. Y. F. R.

* * * *

Voltage at Meter Terminals—The accompanying illustration shows the wiring for meters in our plant. I would like to have some reader check these connections and indicate what



the voltage is across the terminals of the reactive meter at the following points: C to N, N to A and C to A.
Racine, Wis. T. G. L.

* * * *

Charging Storage Battery—I would like to charge the storage batteries in our plant from a 220-volt d. c. exciter circuit of our 2,300-volt a. c. generators. If some readers will show a diagram of connections and a practical method for reducing the voltage, I will appreciate it very much.
Amenia, N. Dak. J. P. C.

Answers Received To Questions Asked

In the January issue Mr. Meisner and Mr. Heinback give the same coil grouping and connections in reply to E. L. of St. Anne de Beaupre. Both are correct for the winding specified.

If I were having this motor rewound I would make up 36 coils, each with half the number of turns in the 18-coil winding and connect them in groups of three coils per pole per phase. This would give a more uniform distribution and make practically no difference in the operating characteristics. CHAS. SUGG.
Atlantic Coast Line Railroad,
Wilmington, N. C.

* * * *

Size of Pulley on a Motor—The writer would like to request readers of Industrial Engineer to indicate what is considered good practice in the dimensions of pulleys for d. c. and a. c. motors. For instance, is it good practice to use a pulley larger than the diameter of the armature? If not, why?
Orange, N. J. R. H. S.

This will answer the question by R. H. S. concerning dimensions of motor pulleys. Pulley dimensions have been standardized by motor manufacturers and depend upon the motor speed and horsepower. Decreasing the pulley diameter increases the strains on the motor shaft and bearings and for this reason each motor has a specified minimum pulley diameter. Maximum diameters are used in applications where speeds higher than the motor speed are required such as in connection with woodworking machinery and grinders. In practice the pulley diameters are limited by the belt speed which should not exceed 5,000 feet per minute.

Standardized pulley dimensions can be obtained from any motor man-

ufacturer and are given in the handbook of the Electric Power Club.

Detroit, Mich. JOHN B. RAKOSKE.

* * * *

Reconnecting Motors for Half Speed—We have two 7½-hp., 60-cycle, 220-volt motors operating at 1800 r.p.m. These motors are connected in two-parallel delta. They have 40 slots with 4 coils in a group. Is it possible to reconnect the winding for a speed of 900 r.p.m. and get as good performance from the motors as when they were connected for 1800 r.p.m.?

Medina, O. C. F. N.

Since the power of a given motor is approximately proportional to the speed, C. F. N. in the January issue cannot expect to reduce the speed of his motors and maintain operating characteristics. At 900 r.p.m. he will get probably less than half the power that he gets at 1800.

CHAS. R. SUGG.
Atlantic Coast Line Railroad.
Wilmington, N. C.

* * * *

In answer to C. F. N. of Medina, Ohio, I want to say that I feel sure he is wrong in stating that there are 40 slots with 4 coils per group in his 7½-hp. motors. If, however, he is right, he may disregard the data given here, and I would say there is something peculiar about these machines.

As C. F. N. states that these motors are running at 1800 r.p.m. and connected 2-parallel delta, we know that these are 3-phase, 4-pole machines. Now with 4-poles per phase we have twelve poles per machine of four coils per pole, making 48 coils. It is impossible to balance 40 coils in twelve poles correctly, even if an irregular grouping of 3 and 4 is used. So we will assume that C. F. N. made a mistake and meant 48 slots instead of 40 slots.

To change these machines to operate at 900 r.p.m. it becomes necessary to change the number of poles per phase from 4 to 8. This will now make 3-phase, 8-poles per phase, or 24-poles per machine. We will now have only two coils per pole. It will be seen here also that if the machine has 40 slots this cannot be done.

The result of the change in connections from 1800 r.p.m. to 900 r.p.m. is as follows: Whereas the machine was 3-phase, 4-poles per phase, 4-coils per pole connected 2-parallel delta, it is now 3-phase, 8-poles per phase, 2-coils per pole, connected 2-parallel delta. The machine will have the same operating characteristics and same electrical efficiency but, of course, it will be reduced one-half in power. The horsepower of the machine after the change is proportional to its changed speed as per the following equation: X : 900 = 7½ : 1800 or 3.75 hp.

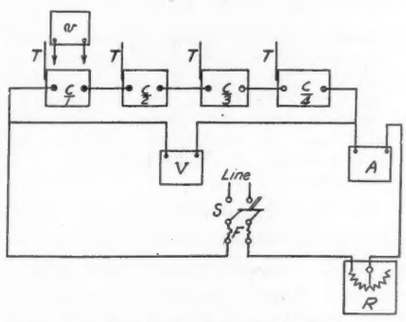
Darby, Pa. GEORGE WM. HANLON.

* * * *

Testing Motor Field Coils—Is it good practice to apply voltage across the shunt fields of a motor for several hours to test for heating? I am having trouble with the blowing of the main fuse on my generator, although the machine is not overloaded. Can you tell what causes this trouble?

New Orleans, La. A. C. H.

Although several answers have been published to the question by A. C. H. regarding the practice of applying voltage across the shunt field coils of a motor, I would like to state my experience, gained from actual tests on many motors and under various conditions of apparent faulty construction or other faults.



Connections for field coil excitation heat test.

In the diagram, *A* is an ammeter; *V* a voltmeter; *v* a voltmeter for testing drop-per-coil; *R* a resistance; $C/_1$, $C/_2$, $C/_3$ and $C/_4$ are coils; *T* indicates thermometers; *F* fuses and *S* a line (d.c.) switch.

I have found that the application of a d.c. voltage not exceeding the normal exciting voltage is not objectionable, and will cause no harm to the coils providing the current sent through them is under control and not above the normal operation value when the motor is in service. The shunt fields are designed for the motor voltage requirements and a certain current value will result under full load on the motor. This field current value is determinable by the use of an ammeter.

With the coils connected according to the accompanying diagram, with the current value being small at the start and increased gradually by means of the resistance until the full load excitation current is established, the thermometers will show the conditions of the various coils and their temperatures should not be allowed to rise over 40 deg. C. for a 40-deg. C. motor or over 50 deg. C. for a 50-deg. C. motor. Normally this rise in temperature can be adjusted by lowering the exciting current after a period of time so that the temperature rise shall be the controlling factor of the test.

It is good practice to test the voltage drop across each coil at the start of the test and any unequal "drop" accounted for before the coils are subjected to further heat tests. If the coils are in good condition the application of a d.c. voltage, across them and with the normal exciting current passing through them, will not cause the temperature rise to become rapid, but will show a gradual rise and a continued equal rise after the maximum is reached.

Any sudden temperature rise should be investigated before damage to the coils results.

If it is desired to maintain a flow of air over the coils during this test a fan should be employed and so located that the amount of air from it, over the coils, is as nearly equal as possible to the amount of air which normally flows over the coils when the armature is in motion and the resulting air from the motor fan is used to keep the coils cool.

NATHANIEL W. BLANCHARD.
Inwood, Long Island, N. Y.

* * * *

Removing Coils From Motors Without Damaging—Is it possible to strip an armature or stator of coils and save these coils for rewinding?

Brooklyn, N. Y. I. T.

In reply to the question by I. T., there are on the market a number of good varnish removers that will work satisfactorily for this purpose, although they must be used with reason. If a liquid will soften the varnish enough to allow the coils to be withdrawn without tearing, it will spoil the insulating quality of the varnish which was absorbed by the covering on the wire. It will probably also ruin the insulating enamel on enameled wire.

The writer has found the following method satisfactory for stripping d. c. armatures up to 10 hp. in size, where we want to save the coils: The armature is soaked overnight in gasoline, standing it on end with the commutator above the surface, in an old barrel provided with a tight cover. This method has the advantage of loosening the varnish and making it easy to remove the old tape, etc., from the coils. After

taking out of the gasoline the coils are left in the air until all the gasoline has evaporated.

On small and large a. c. stators the best method is to run current through the winding until it becomes warm enough to soften the varnish. If the coils are to be saved, the current should be turned off before the winding starts to smoke. On large d. c. machines a gas torch can be used to heat the core. If the torch is applied before the wedges are removed, the coils will not be burned. When only a few coils are to be lifted or removed, the top and bottom leads of the defective coils are lifted out of the commutator and all the top leads attached to one line and the bottom leads to the other line. Then current is allowed to flow through the coils until they are warm enough to be removed.

When the armature or stator of a small fan or fractional horsepower motor requires complete winding and a new commutator, the machine is put in a boiling solution of sal soda. It is allowed to boil for at least three hours. This loosens all the varnish and makes the motor easy to strip, although it destroys the commutator and any fiber end rings. The core must be baked dry before it is rewound in order to drive out the moisture between the laminations.

Detroit, Mich. A. C. ROE.

* * * *

This will answer I. T.'s request for information on stripping an armature or stator and saving the coils for rewinding.

It is impossible to do this with motors that have closed slots and that have been dipped, especially if dipped in Bakelite. But if they have open slots and have been dipped in varnish insulation, and they use formed coils, they can be lifted out of the slots and can be saved for rewinding. The first few may be spoiled but the rest can be saved. This can be done with a long tapered piece of fiber which will fit the slot in the armature or stator. By driving it from one end between the coils they can be lifted up without bending or injuring the coils, providing the insulation is not dried too much. CARL STEINIGER.

Chicago, Ill.

* * * *

In regard to the inquiry by I. T. in INDUSTRIAL ENGINEER concerning the removing of coils from motors without damaging them, I would say that in certain cases this can be done and it pays to do so. If time is important, however, the quickest way is to strip the motor and put in new coils throughout. If some extra time is allowable, the coils can be unsoldered. wedges removed and the coils lifted without damage. This applies to motors that have not been overheated enough to char the insulation.

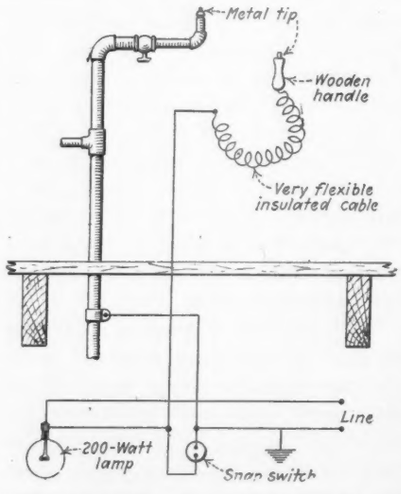
After the coils have been removed, inspect them carefully for damage, particularly at the ends. The good coils can be cleaned up, dipped in insulating varnish, baked and with the addition of new paper cells will function as when new. I have used this method on motors from 5 hp., 110 volts, to 500 hp., 2,300 volts, with good results. PHILIP N. EMIGH.

Chief Engineer,
Mountain Water Supply Co.,
Indian Creek, Pa.

* * * *

Lighting Gas by Electricity—I would appreciate details of a method by which a 60-cycle, 110-volt, alternating current circuit can be used to light a gas jet instead of using matches. A sketch of a device for this purpose would be helpful.
Wilmington, Del. J. H. G.

The use of 110-volt, 60-cycle alternating current is not to be recommended for lighting gas unless stepped down to a low potential, as there is always great danger of accidentally receiving a serious shock. The accompanying sketch, however, shows a frequently used scheme which gives complete satisfaction and is perfectly safe if precaution is taken not to touch the tip of the handle or the bare wire due to worn insulation, while standing on a wet floor or touching any grounded object with the other hand. If a gas jet is used, it should have a metal tip. In operation, it is simply necessary to turn on the gas and tap or scratch the end of the handle on the gas burner or jet. The resulting spark readily ignites the gas.



Use the cellar lamp in connection with a gas lighter.

The snap switch is necessary only when the lamp is to be lighted when the gas lighter is not in use.

The lamp used may be employed for this purpose alone, or may be ordinarily intended for illumination.

If a small transformer is available, it should be wound for any voltage between 3 and 10 volts and may be connected with or without resistance, depending on the voltage and size of the transformer. About 50 volt-amp. is the right capacity. This scheme, however, consumes a small amount of power continuously unless the primary is disconnected each time, which, of course, lessens its convenience.

There are standard gas jet lighters on the market which operate from a battery or a low-voltage transformer. In one type, the gas is turned on manually and is lighted by pulling a small chain while in another type the pushing of a button at some distant point automatically turns on the gas and lights it, while the pushing of another button turns off the gas, thus giving the advantages of a remotely controlled light when using gas. VICTOR H. TODD.

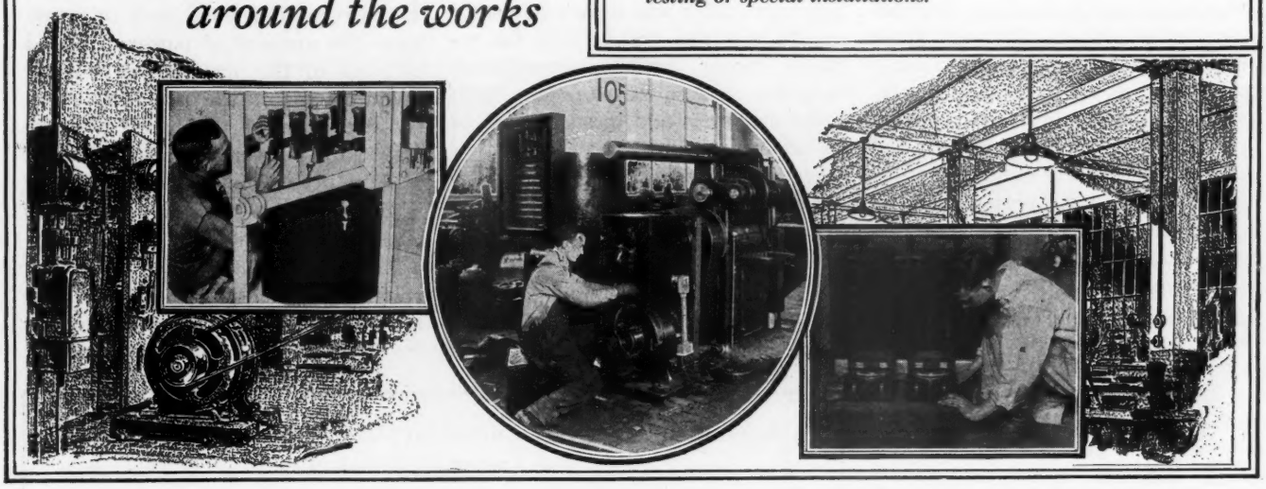
Summit, N. J.

Omission in Item on Page 108 of February Issue

AN UNFORTUNATE omission occurred in the item on page 108 of the February issue of INDUSTRIAL ENGINEER which answered the question on RLM Standard Dome Reflectors. This omission was in the second sentence which should read: "Several years ago, the Illuminating Engineer of one of the lamp manufacturers, feeling dissatisfied with the types of industrial reflectors being sold for use with Mazda C lamps, called a conference of all the leading manufacturers of steel reflectors, and of the illuminating engineers of the Mazda lamp manufacturers." The omission occurred by the dropping out of the words "leading manufacturers of steel reflectors and of," which made one full line of the original copy, and was simply skipped when typing the original matter. This is an important reference to the origin of the conference which led to the origination of the RLM Standard Dome Reflector.—EDITORS.

SERVICE
around the works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Care in Oiling Bearings of Motors Will Prevent Trouble

OILING motors appears to be a simple enough procedure, but unless the oiler observes certain precautions trouble is likely to result. For example, flooding the bearings so that the oil overflows or runs out frequently results, if the motor is a direct-current machine, in the oil getting on the commutator, brushes and brush holders. In addition to the commutator trouble which the oil can cause, it soon takes up carbon dust and other dirt and forms a sticky paste which may prevent the brushes from working properly in the holders. Oil overflowing from the pulley end of the motor will be drawn into the armature and thrown off onto the field coils and frame, where it forms a sticky coating which is not only hard to remove, but is, in time, injurious to the insulation. Those who take pride in clean machines take pains to prevent excess oil overflowing to absorb dust.

Before adding oil to the bearings, the oiler should find out whether the oil rings are working properly, if the bearings are provided with these, and also determine the level of the oil. Otherwise there is danger of putting in too much oil.

Bearings should be drained at intervals depending on the service conditions, particularly with reference to the amount of dust and dirt in the air, and filled to the proper level with fresh or carefully filtered, used oil. After some weeks or months of use the oil in the bearings of a motor or machine becomes dirty and unless the grit and foreign matter is removed occasionally it will cause undue and unnecessary wear of the bearings. — JOS. B. HUMPHREY.

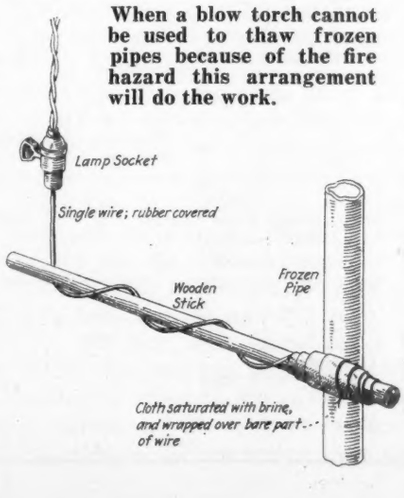
Chief Electrician,
Blatz Brewing Co.,
Milwaukee, Wis.

Simple Method of Thawing Frozen Water Pipes By Electricity

THERE are cases where frozen water-pipes cannot be cleared safely by use of a blow-torch, and where hot water used to melt them will injure ceilings, or do other damage. Where lighting current is to be had, a simple and effective thawing outfit can be made as follows:

Remove from the end of a piece of electric wire all insulation for a distance of 6 in. and wrap this bare part around the end of a stick which is long enough to reach the place to be thawed. Wind at least ten layers of cloth around the bare wire so that it completely covers the copper and tie the cloth in place with string. Run the wire to the nearest lamp-socket, and connect by means of an attachment plug with the wire fastened under one of its screws, the other screw left clear. Dip the cloth end of the stick in strong salt water, and apply to the pipe. If there is no action, reverse the plug, or attach the wire under the other screw. When connections are right the cloth touching the pipe will begin to steam. It should be kept wet by frequently dipping. DEXTER W. ALLIS.

Whitman, Mass.


Lamp Socket
Single wire; rubber covered
Wooden Stick
Frozen Pipe
Cloth saturated with brine, and wrapped over bare part of wire

When a blow torch cannot be used to thaw frozen pipes because of the fire hazard this arrangement will do the work.

Some of the Causes of Ring-Fire and How It Can Be Prevented

RING-FIRE is a term usually applied to an ailment most frequently met in slow or moderate speed direct-current machines. It can be recognized by characteristic thin streaks of fire that appear to extend from one brush position to the next and might deceive one who is unfamiliar with the symptom into thinking that the trouble had its origin in the brushes themselves. The point of maximum voltage between commutator segments is the position midway between any two brush holders, and the arcing reaches its maximum at that point. Ring-fire usually results from a partial breakdown of the mica insulation between adjacent commutator segments and the burning is quite localized as a rule. The points at which it takes place are often only a fraction of an inch in length, but the continuous arcing

eventually burns holes sufficiently deep to cause a breakdown in the insulation of one or more commutator segments and the temporary shutdown of a machine.

Undercutting of mica is a fruitful source of ring-fire. Although freedom may be secured from trouble due to high mica, the grooves resulting from undercutting readily collect foreign matter, such as copper and carbon dust, which are highly conductive, and these, with perhaps a little oil thrown from a leaky bearing, are sufficient to start local burning between segments. Unfortunately, it is not always possible to use brushes which are sufficiently abrasive to keep down the level of the mica insulation to that of the commutator bars, and therefore it is often necessary to undercut the mica. This usually consists in cutting grooves to a depth of from 1/32 to 1/16 inch. Often the point of a file is used as the tool, making a V-shaped groove whose edges remain above the commutator bars and, through impairing the brush contact, probably assist the development of the ring-fire by charring any foreign matter that gets into the grooves.

Perhaps the best method of obviating ring-fire is to cut down the mica for some distance and, so as to leave no grooves in which dust can accumulate, refill with some material which is a good insulator and will wear down with the commutator bars. Plaster of paris is suitable for this purpose. The first operation is to turn the commutator free of flats and irregularities. Next, a semi-circular groove about ¼ in. deep is turned in the commutator close to the armature conductors. Care must be taken to see that all short-circuits between bars, especially in the edges of the grooves, are cleared after turning. The mica between the bars is then cut to a depth of from 3/16 to ¼ in. If no other means are available, a piece of hack saw fastened in a suitable holder may be employed. In all cases the mica must be cut square to the bottom of the grooves.

The plaster of paris for filling up the grooves should be perfectly clean and free from lumps. The plaster under normal conditions sets rapidly but one part of dextrine mixed with seven of plaster of paris will retard hardening. The filling should be worked into the grooves between the commutator bars until they are filled solid. At least a day is necessary for setting, when the commutator should be smoothed to remove all roughness occasioned while cutting down the mica. After this treatment the commutator will have a perfectly smooth surface which will be retained under running conditions. Ring-fire seldom develops in high-speed machines and in such cases as do occur any filling similar to that described is undesirable, as centrifugal force tends to dislodge the filling. However, for machines of slow and medium speeds the method of treatment referred to is very effective.

R. TOKEA.

Walton-on-the-Thames, Surrey, England

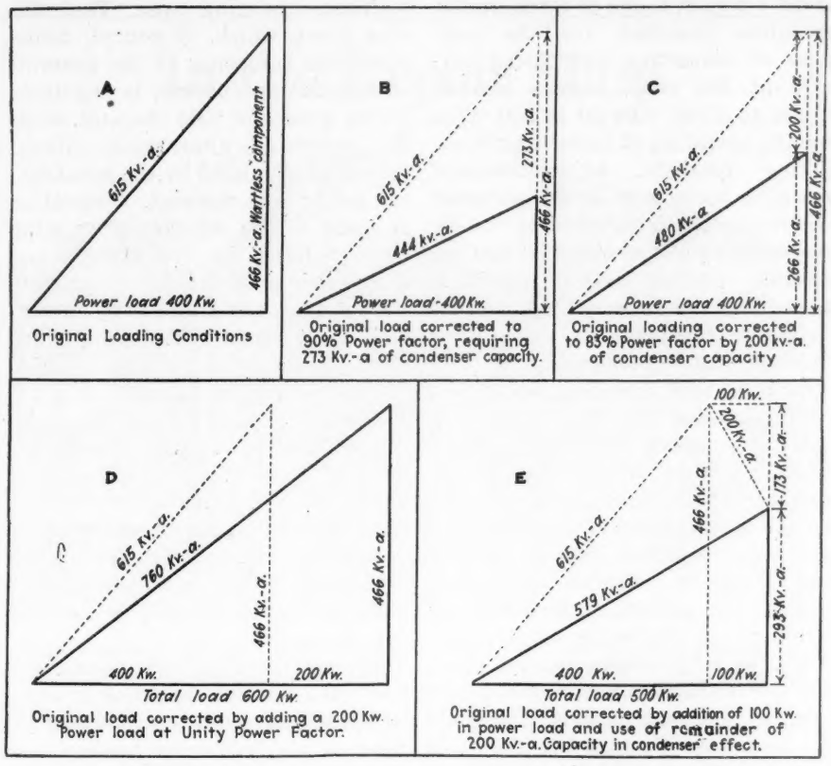
Determination of Power Required in the Operation of Sawmill Machinery

IN THE accompanying table are the results of some tests to determine the amount of power required by some of the machines in a large sawmill. All of the machines, with the exception of the band saw, are driven by 440-volt, 3 phase, squirrel cage induction motors; the band saw is driven by a variable speed slip ring induction motor.

The test was conducted by taking volt- and ammeter readings of the input to each motor. Inasmuch as the loads on the motors are subjec-

Amount of Power Required to Drive Sawmill Machinery for Various Operations

Machine	Speed R.P.M.	Piece Handled	Operation	Feed Feet per Min.	Horse-power Required	Remarks
Gang saw, 36 in. x 12 in.	258	Cedar cant, 24 in. x 12 in.	Cutting into 1-inch boards	7½	93	Crank not balanced
Gang saw, 36 in. x 12 in.	258	Cedar cant, 6 in. x 34 in.	Cutting into 1-inch boards	15	115	
Gang saw, 24 in. x 8 in.	260	Cedar cant, 15 in. x 4 in.	Cutting into 1-inch boards	6	20	Has balanced crank
Single cut, 8-inch band saw	Rim speed 10,000 ft. per min.	Fir cant, 12-in.	Cutting into 1-inch boards	112	100	Has variable-speed motor
Single cut, 8-inch band saw	Rim speed 10,000 ft. per min.	Cedar cant, 10-in.	Cutting into 1-inch boards	160	110	
Shingle machine			Cutting shingles		60	Without balance wheel
Shingle machine			Run idle		10	
Shingle machine			Cutting shingles		45	With 175-lb. balance wheel
Set work on saw carriage		Cedar log, 5-ft. diameter, 18 ft. long	Move log	20	12	
Berlin planer No. 350	3,000 (Side-and-top heads)	Cedar, 1 in. x 6 in.	Plane all around	220	55	
Centrifugal pump	1,800				20	Pump suction, 5 in.; discharge, 3 in.; suction lift, 16 ft.; head, 125 ft.



to wide fluctuations, the results given in the table must be considered as close approximations. Also, in calculating the horsepower required by the different machines, the efficiency of the motors was disregarded, but account was taken of the 70 per cent power factor which obtains in our mill. F. G. BONN.

Port Hammond, B. C.
Canada.

Calculating Generator Capacity for Use as Condenser to Correct Power Factor

The possibilities in the use of a generator as a condenser to correct the power factor are explained in this item and illustrated graphically when applied under different conditions.

IT IS often found desirable to use a generator as a condenser for power-factor correction. The writer has noted, however, that in some cases a generator has been either considered for such service or put into use without first really knowing what the result might be. The following points cover the conditions most commonly encountered and should be carefully considered before attempting to make such power-factor improvements in any system: (1) A thorough check of the system should be made, covering especially the average maximum load and the power factor of the feeder systems. (2) The generator must correspond in the characteristics of phase, voltage and frequency with the system with which it is to be used. (3) Will the generator be used as a motor, either wholly or in part, for additional load? (4) Will it be used as a motor, either wholly or in part, for existing load, or will it be used as a condenser only?

A concrete example will help to make clear the method of solving these problems. Assuming an existing average maximum load of 400 kw. with a power-factor of 65 per cent, it is desired to increase the power-factor to 90 per cent. It is also assumed, for the purpose of this example, that a generator of 200 kva. capacity is available and that the windings of the generator are such that it will carry 200 kva. at zero leading power-factor.

Case 1. Generator to be used as a condenser only. The assumed 400 kw. load at 65 per cent power-factor makes a kilovolt-ampere load of $400 \div 0.65 = 615$ kva. The wattless lagging component of this load amounts to $\sqrt{(615^2 - 400^2)} = 466$ kva. (See Fig. A.) With the same power load of 400 kw. carried at 90 per cent power-factor, the kilovolt-ampere load would be $400 \div 0.90 = 444$ kva. (See Fig. B.) With a load of 444 kva. and a corresponding power load of 400 kw., the wattless component is $\sqrt{(444^2 - 400^2)} = 193$ kva. The difference between 466 and 193 wattless kva., 273 kva., must be made up in leading wattless kva. supplied by the condenser effect if the power-factor is increased from 65 to 90 per cent. But this is 73 kva. more than the assumed capacity of the generator available. Consequently it cannot be used to accomplish the desired result.

With a wattless component of load amounting, as in this case, to 466 kva. corrected by the assumed 200 kva. of condenser generator capacity, the resulting wattless component would be 466—200=266 kva. (See Fig. C.) With a load of 400 kw. and a wattless component of 266 kva., the resulting power-factor would be 83 per cent, $400 \div \sqrt{(400^2 + 266^2)} = 0.83$.

Case 2. Generator to be used as a motor to carry its full capacity (200 kva.) in additional load. Under this condition, with the added load carried at unity power-factor, the wattless component remains at 466 kva. and the actual power becomes 400+200=600 kw. The total kilovolt-ampere load amounts to $\sqrt{(600^2 + 466^2)} = 760$ kva. The new power-factor will be 80 per cent ($600 \div 760 = 0.80$).

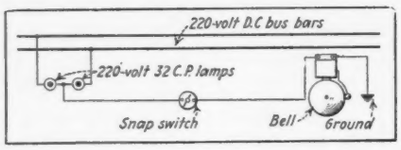
Case 3. Generator to be used to carry an additional power load of 100 kw. with the remaining 100 kva. capacity used for condenser effect. With the machine carrying a power load of 100 kw., the total condenser capacity available from a 200 kw. machine will amount to $\sqrt{(200^2 - 100^2)} = 173$ kva. (See Fig. E.) Subtracting this amount from the wattless component of the original system leaves a resultant wattless component of 293 kva. (466—173=293). With the added 100 kw. of power, the total power load on the system is 500 kw. (400+100=500), and with a wattless component of 293 kva., the total kilovolt-ampere load amounts to $\sqrt{(500^2 + 293^2)} = 579$ kva. With a power load of 500 kw. and a corresponding 579 kva. load, the power-factor becomes 86 per cent ($500 \div 579 = 0.86$).

Case 4. Generator to be used at its full rating as a motor to carry existing load. The simplest method in this case is to take out of service for a time the motor or motors to be replaced by the change and then check the existing power-factor. A new set of load readings should be taken at this time, and with the new load and power-factor values the computations may be carried on as in Case 2. R. W. LLOYD.

Ainsworth, B. C.

Lamps and a Bell Connected to Give an Alarm When Circuit Is Grounded

A SIMPLE scheme for detecting grounds has operated successfully in the foundry in which I am located. The electrical system in this foundry furnishes energy for traveling cranes equipped with 220-volt motors. In the sub-station are two motor-generator sets with switchboard and other equipment, and adjacent to this is the electrical repair shop. Most of our time is spent in the repair shop, and the plant is not large enough to employ an operator for the switchboard. Therefore a ground of an intermittent character on a crane motor may be present for some time before it is noticed.



A ground on the system causes a lamp to light and the bell to ring.

Two lamps are used as ground detectors and are connected as shown in the sketch. A bell and a snap switch are inserted in the ground line. When the system becomes grounded the bell as well as one lamp gives the alarm. The snap switch is then turned off until the ground is removed, to stop burning of the contacts. For about three years this has decreased repair work by helping to remove the trouble before damage is done.

P. WHALEN.
Fort William, Ont., Can.

Motor-Generator Set Connected to Render Various Services

THE accompanying diagram shows the method of connecting which made it possible to use an ordinary motor-generator set for any of the following purposes: (1) Generator for 250-volt direct current; (2) generator for 440-volt, 3-phase, 60-cycle alternating current; (3) electric welding service; (4) synchronous condenser to improve power factor.

The unit is a 350-kw. Allis-Chalmers motor-generator set of the 3-bearing, direct-connected type and consists of a compound wound direct-current generator and a synchronous motor which has its field excited from the main 250-volt direct-current buses. The normal speed of the set is 600 r.p.m. It is one of three similar machines installed for the purpose of converting alternating current at 440 volts, 3-phase and 60 cycles to direct current at 250 volts, for the operating of traveling cranes, lifting magnets, adjustable-speed machine tools, and other purposes where the characteristics of the direct-current motor made its use desirable. Central station power is used for the alternating current drives in the plant as well as for driving the motor-generator sets which in turn furnish the direct-current power for the cranes and other equipment mentioned above. Formerly when this service was interrupted the consequences were serious. The stopping of gas producers and blowers caused damage and delay at heating furnaces, and lack of power for pumps caused a heavy drain on the city water supply. Perhaps the most serious feature, however, was the possibility of about 80 tons of open-hearth steel "freezing" in the ladles. To guard against this possibility a steam-driven generator was installed to furnish direct current at 250 volts. Now when an interruption occurs this unit is started immediately and direct current is thrown on the buses to provide power for the ladle cranes. If alternating current power does not come on within three or four minutes the main 22,000-volt alternating-current service switch is opened and the motor-generator set started from the direct-current end by the graduating resistance. The series field of the direct-current generator is short-circuited by a switch and the brushes rocked forward to provide the proper commutation for running as a motor. These brush positions are marked to facilitate changing over. The running speed which, of course, determines the frequency of the generated alternating current, is regulated by the generator field rheostat, while the generated alternating current voltage is regulated by the synchronous motor field rheostat. Connection is made to the 440-volt alternating current buses by the starter and line switch provided for controlling the set from the alternating current end. Pilot lamps (not shown) warn the operator when central station voltage returns to normal.

The set is used for electric welding by short-circuiting the series-field winding of the direct-current generator and reducing the voltage to the desired value by manipulation of the field rheostat. The graduating resistance is used as a steadying resistance and for controlling the welding current.

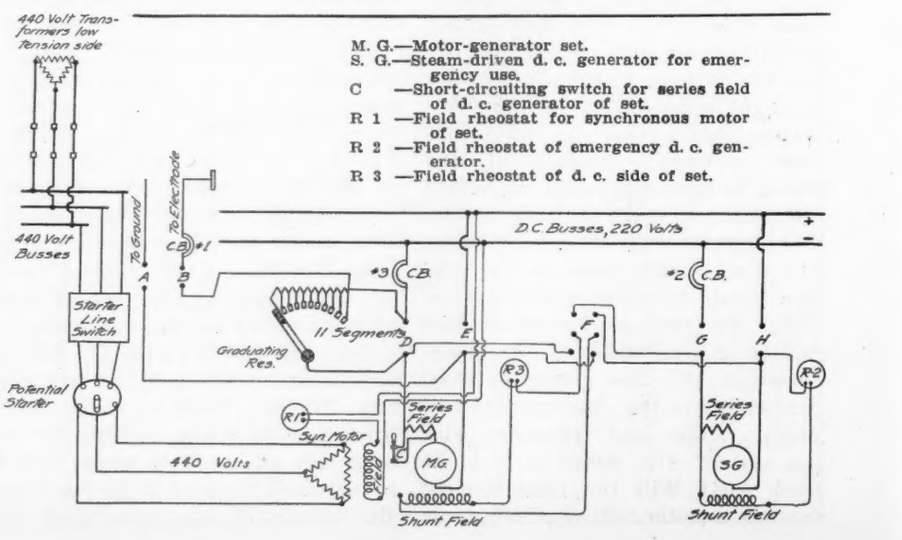
During the times when the set is not being used to supply alternating or direct current line power it is used as a synchronous condenser to improve the power factor, the increase being on the average about 15 per cent. As the welding current may be taken off at normal speed and reduced voltage it follows that the set may be used to perform these duties simultaneously.

Chief Electrician, Edgewater Steel Co., Oakmont, Pa.

A. W. MCAULY.

Diagram of connections for motor generator set used for various purposes.

This set is normally driven from the a. c. end but is used to convert d. c. energy supplied in emergencies by a local steam-driven unit to a. c. energy in case of a failure of the central station a. c. service. This set may also be used to supply energy for welding service at the same time that it operates as a condenser to improve the power factor.



In the Repair Shop

This section is devoted to all sorts of electrical repair work, large and small. Special attention is given to tools found convenient at the shop bench and short cuts or improved methods. Articles on these subjects are always welcome.

Simple Tool May Be Used for Many Purposes in Repair Shop

A TOOL which was developed in our repair shop and has been found to be very useful for a number of different purposes is shown in the accompanying illustration. As will be seen it is made of hexagon tool steel bar, with the ends flattened and formed as indicated. For our purposes it has been found advisable to make this tool in three different sizes, 14 in., 16 in. and 20 in. in length, with the other dimensions altered correspondingly.

The thin, curved end of the tool, designated as *Y* in the illustration, is used for lifting armature coils, forming the ends of coils on the core, stretching coils when they are being placed in the slots, and so on. The other end, *X*, is shaped much like the end of a pinch bar and is used for opening boxes, pinching off gears, pinions, pulleys and similar work.

When making this tool care should be taken to make all of the edges round and smooth, so as to avoid possibility of injury to the insulation on coils. Also, the curvature of the coil-lifting end of the tool should be such that the point is high enough to clear the top edge of the coil slot when the tool is on the bottom of the slot. As shown at *D*, the point *Y* should be considerably thicker than the curved portion behind it.

Chief Electrician, Walworth Mfg. Co. Kewanee, Ill. E. J. FORD.

This tool can be used for lifting armature coils and as a pinch bar. With the simple directions given here any or all three sizes of bar can be made easily.

Simple Suggestions to Be Followed When Dipping and Baking Armatures

EXPERIENCE gained in the treatment of a large number of motor armatures has indicated certain methods which should be followed to produce the best results. Careful draining after dipping and thorough baking are very important points. The general process may be divided into two classes, depending on whether the armature requires overhauling or a complete rewinding. Where it is desired to overhaul it, the recommended steps are as follows:

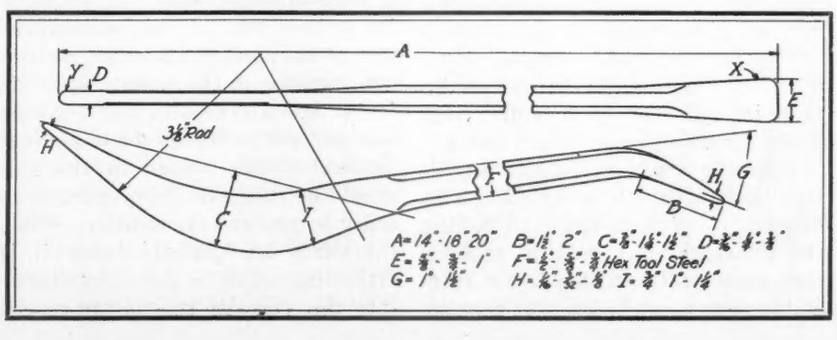
When the armature is very dirty remove the accumulation of dirt and grease with a scraper. Then clean with benzine or gasoline by brushing or dipping. Remove the bands and insulation on the end windings and make any necessary repairs. Make sure that the core bands are tight and that the coils are tight in the slots. If either is loose, reband, placing a filler in the same slot, when required, to get pressure on the coil, at the same time making sure to have the bands down on the iron.

Where wedges are used inspect for tightness, and when it is thought that they will not tighten when dipped rewedge, using fillers under wedges to make the coils tight. Place temporary bands on armatures if there is a tendency for the coils to spring out of position when dipped. Place the bands so that the armatures will drain readily after dipping. Some operators may wish to dip and bake armatures without removing bands or hoops. In such cases care must be taken to see that the armatures drain and bake out.

Heat the armature in an oven with freely circulating air, using an oven temperature of 200 deg. to 220 deg. Fahr., for the length of time given: Armatures below 18-in. in diameter, twelve hours; armatures 18-in. to 30-in. diameter, eighteen hours; armatures over 30-in. diameter, twenty-four hours.

It has been suggested by one operator that armatures can be preheated in a storage furnace utilizing the waste heat from the main oven and that thus a saving may be effected, provided that the arrangement can be worked out satisfactorily.

While the armature is still hot, dip it in a good grade of baking insulating varnish. A clear amber baking insulating varnish with a specific gravity of 0.835 is recommended, but other varnishes may be used, the specific gravity depending upon the varnish and the thickness of the varnish coat desired.

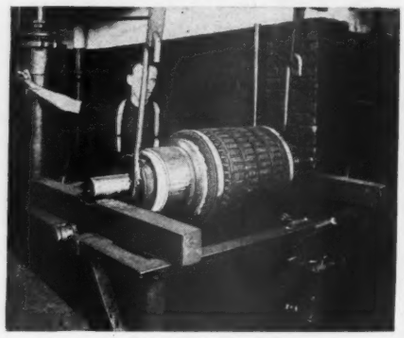


Should the varnish be too heavy thin with benzine. Dip the armature in a vertical position, commutator end up, varnish coming only to the commutator neck, allowing the armature to remain in the varnish for five minutes. If vapor rises from the varnish in large quantities, it indicates that the armature was too warm when dipped. Place all double-commutator armatures in a horizontal position so they can be rotated in varnish to twice the slot depth. In case they cannot be rotated as described, pour varnish over the armature until the windings are filled. After an armature has been dipped, wash off the varnish on all finished metal parts with benzine. The commutator should not be immersed, as varnish may get inside of the commutator and be trapped, neither draining out nor baking. Such a condition is undesirable. Some operators roll armatures in a tank, instead of completely dipping them, and apparently get good results. When this is done the armatures should be rotated slowly several times to insure that all coils are thoroughly soaked with the varnish.

Drain at room temperature until dripping ceases, which will require fifteen to twenty minutes. Place the armature in such a position that there will be no pocketing of varnish in the winding or iron. When the armature is such as to require draining in other than a vertical position, turning will be necessary to avoid the gathering of varnish at one point, the amount of turning depending upon the general construction of the armature. It has been suggested that this draining can be done by spinning the armature in a lathe provided with a shield or cover to catch the surplus varnish.

After dipping and draining bake the armature in an oven at a temperature of 200 deg. to 220 deg. Fahr. until it is dry. This can be determined by taking the insulation resistance. For most cases the length of time given here will be sufficient to dry the armature: Below 12-in. diameter, forty-eight hours; 12-in. to 30-in. diameter, sixty hours; over 30-in. diameter, seventy-two hours.

Bake the armature in such a position that there will be no pockets of varnish when it is dry. In baking the armatures in a vertical position care must be taken in placing them in the oven so as to get free passage of air through the air ducts and around them. Ventilation is necessary to obtain the best results in baking. When an armature is so constructed that varnish will pocket when the armature is baked vertically, or in the case of dipping and baking with end bands in place, bake



Through an arrangement such as this the armature may be held in a convenient position for banding or tightening the coils while overhauling preparatory to dipping.

in a horizontal position. Such armatures are ventilated with radial air ducts. Armatures baked in this position should be turned during baking to avoid any gathering of varnish at one side.

After taking from oven, true up commutator face and neck, applying hoods at front and rear and the end bands. Fill hoods and coat surface by brushing on baking varnish. Place in oven to set varnish, applying as many additional coats as desired. Undercut the commutator and paint the armature with black air-drying insulating varnish, if a clear varnish has been used and a black finish is desired.

JOHN S. DEAN.
Motor Engineering Department,
Westinghouse Electric & Manufacturing Co.,
East Pittsburgh, Pa.

How Motor Speed Was Reduced Without Changing Horsepower

ORDINARILY the speed of a motor cannot be lowered greatly without at the same time lowering the horsepower. If the horsepower is kept the same the current per slot will increase in the same proportion as the speed decreases. If the current per slot increases the total cross section of the copper in the slot should be increased in proportion in order to prevent overheating. When the wires are packed closely it is often impossible to put more copper into the slot and this is the reason it is not possible to decrease the speed without decreasing the horsepower. Sometimes, however, a more compact insulation may be used and thus more room will be allowed for the copper. If the insulation is for a rather high voltage, some of it may be eliminated if the motor is rewound for a lower voltage.

A direct-current motor of which the speed could be lowered without affecting the power came into the shop not long ago. This was a case in which more wire could be squeezed into the slot. The motor in question was a ½-hp., 110-volt, 4-amp., two-pole, shunt-wound machine rated at 2,150 r.p.m. It was desired to keep the same horsepower and voltage but to change the speed to 1,700 r.p.m.

Now the speed of a shunt motor with constant field strength will change in inverse proportion to the change in the number of turns per armature coil. When the motor came in, the coils had thirty turns of one No. 22 double-cotton-covered wire. To decrease the speed, the number of turns had to be increased. The number of turns for 1,700 r.p.m. would equal $(30 \times 2{,}150) \div 1{,}700 =$ about 38 turns.

The current per turn must remain the same if the motor is still going to carry ½ hp. This means that the wire must be no smaller, provided, of course, that the wire is already carrying about the proper current for its size. In standard motors the wire is carrying about the correct amperage. Therefore, if the wire must remain the same in size, the question was: Can the slot accommodate the thirty-eight turns when originally it had only thirty turns? Fortunately, it was found by trial that thirty-eight turns could be put into the slot. In fact, using single-cotton-covered enameled wire it was found that No. 21 gage could be employed with thirty-eight turns per coil. This larger size was consequently used.

In fact a larger size than the original was desired because the ventilation at the lower speed would be poorer. Also the voltage drop in the armature would be greater with thirty-eight turns than with thirty of the same size. The pitch was left at 1 and 9, as it was before. This motor had eighteen armature slots and eighteen commutator bars.

In some cases instead of increas-

ing the number of turns, the same effect may be obtained by increasing the chord factor. As an example, suppose a motor has thirty turns per coil and a chord factor of 85 per cent. The speed of this motor could be reduced say 10 per cent by increasing the turns in the ratio of 100 to 90, which would give thirty-three turns. Or the same result might be accomplished by increasing the chord factor in the ratio of 100 to 90 which gives 93.5 per cent chord factor. A combination of these methods can be used if desirable.

Detroit, Mich. A. C. ROE.

Equipment and Materials Needed for a Small Repair Shop

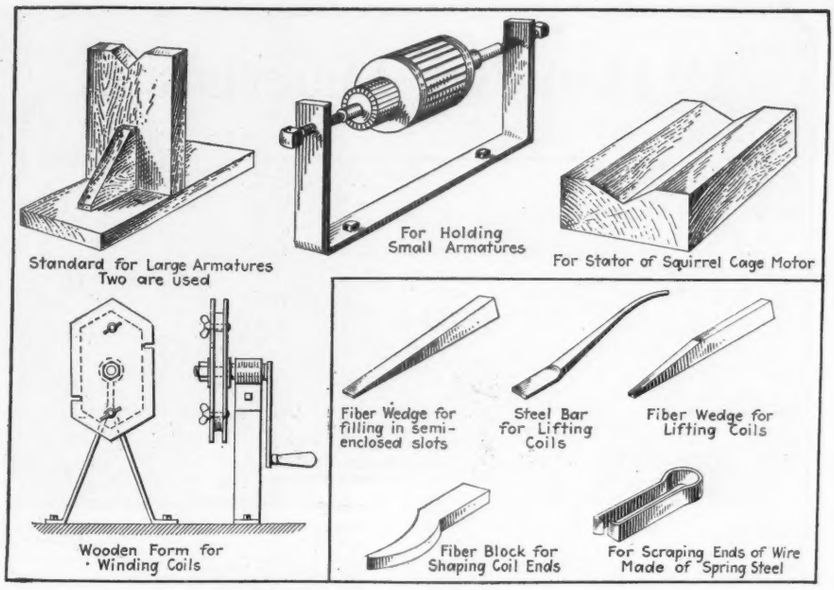
TWO things are necessary when starting up a small repair shop. The first is a certain amount of knowledge; the second is proper equipment. The few necessary tools required by the small shop are described in good books on armature winding. The number and type of tools will depend, to a large extent, on the kind and size of motors repaired. A large part of the equipment can be made in the shop. A small lathe will be found very convenient for turning down commutators, making small bearings and bushings, winding magnets and solenoids, and so on.

For holding large armatures while being wound, a standard is often used similar to the one shown in the accompanying drawing. A form of large C-clamp is often used for small armatures. For the stator of a squirrel-cage motor a V-block as shown will be found convenient.

Small stator and armature coils can be wound in a form held in one hand while the wire is fed with the other, but such an arrangement is very slow. It is quite an easy matter to rig up a form that can be turned with a crank.

A few hand tools will be required for shaping the ends of coils, filling the slots, lifting coils and driving and removing wedges. Some of these are shown in the drawing. Tools used for handling the wire directly should be made of horn fiber or some such material and all sharp edges should be removed.

The testing equipment of a small shop usually consists mainly of a growler, millivolt meter, a compass and a magneto. Some shops use only a magneto for testing for grounds on low-voltage machines while others have special transformers for subjecting the windings to high-potential tests.



Some useful tools for the repair shop.

Regarding supplies, a small shop will find that single-cotton-covered enameled magnet wire will answer most requirements. Sizes from No. 14 to No. 30 should be carried. The amounts will depend upon the amount of work done and length of time required to receive material from jobbers. Often jobbers carrying a good line of electrical supplies have a very poor stock of magnet wire and other motor-winding material. In a small town where 50 to 100 motors, ranging in size from ¼ hp. to 15 or 20 hp., are wound per year and shipments of wire can be received from the jobber inside of three or four days, the following stock should be ample: 5 lb. of No. 30 to No. 27; 10 lb. of No. 26 to No. 20, and 25 lb. of No. 19 to No. 14. I realize that this is not a large stock, but one can "get by" with it.

The following stock of insulating materials will be found satisfactory: Cotton tape, ½-in. and ¾-in.; cotton sleeving; fishpaper, medium heavy; red rope paper, medium heavy; varnished cambric, medium heavy; red fiber sheet, 1/16 in. thick; slot wedges; varnished sleeving, about ⅛ in. diam.; insulating varnish, air-drying and baking; linotape, ¾ in. wide; varnished tubing, ⅛ in. inside diam.

We generally use a combination of fishpaper and varnished cambric, or rope paper and varnished cambric, with the cambric next to the coil for slot insulation. We often use a heavy varnished cambric for phase group insulation. Slot wedges can be bought from manufacturers, but very few jobbers carry them. We often have maple wedges made at a wood shop where a good jointer and circular saw are available. In this way we can get them the exact width and thickness required, and when we want them. With the exception of the varnished tubing, which is sometimes difficult to secure, all of the material mentioned in this list can be purchased from most jobbers. This tubing is not absolutely necessary for motor work but it makes a much better job of stator work and the like than does cotton sleeving.

For getting knowledge on how to repair, experience is the best teacher. This should be supplemented by school courses or study at home. It is well to practice on an armature or stator, using old wire or string.

If a shop is in business for itself the proper charge for repairing is a question which will be asked. The surest way is to find out what the nearby shops are charging. A few lists on motor-repair costs have been published. One will be found in Braymer's Armature Winding and Motor Repair (McGraw-Hill). Another will be found in the February (1922) issue of INDUSTRIAL ENGINEER. A very rough way to get at the cost of rewinding a squirrel-cage motor is to say that it will cost one-half the original cost of the motor.

J. P. COLLOPY.
Owner and Manager,
Motor Repair Shop,
Fort Collins, Colo.

Handling Materials

Better ways to transport and handle raw and finished parts in and around the works will be discussed in this section.

Overcoming a Difference in Floor Level Between Buildings By Using an Elevator Instead of a Ramp

IT IS not uncommon in many plants, particularly those in which a modern addition has been added to an old building, to find a difference in floor levels which interferes with trucking from one department to another. The ordinary method of overcoming this difficulty is by building a ramp. There are two drawbacks to this method, however, in that ramps occupy considerable space and extend back into the plant if the grade is to be low enough to push trucks by hand. Even then helpers are usually necessary to boost heavy loads up the grade. Ramps also constitute a rather serious slipping hazard when taking loads down the grade.

To overcome a difference in floor levels of about 2 ft. the Economy Engineering Company (Chicago, Ill.) power-driven, portable electric elevator installation shown in the accompanying illustration was made at the plant of the Hygrade Lamp Company, Salem, Mass. Here, however, instead of leaving the wheels on the elevator and making it portable, it is placed in a pit so that the platform of the elevator is at the floor level as shown in the illustration at the left. The elevator motor is operated by the trucker from the platform through a rope control.

Installing a Conveyor to Perform a Complicated Series of Handling Operations

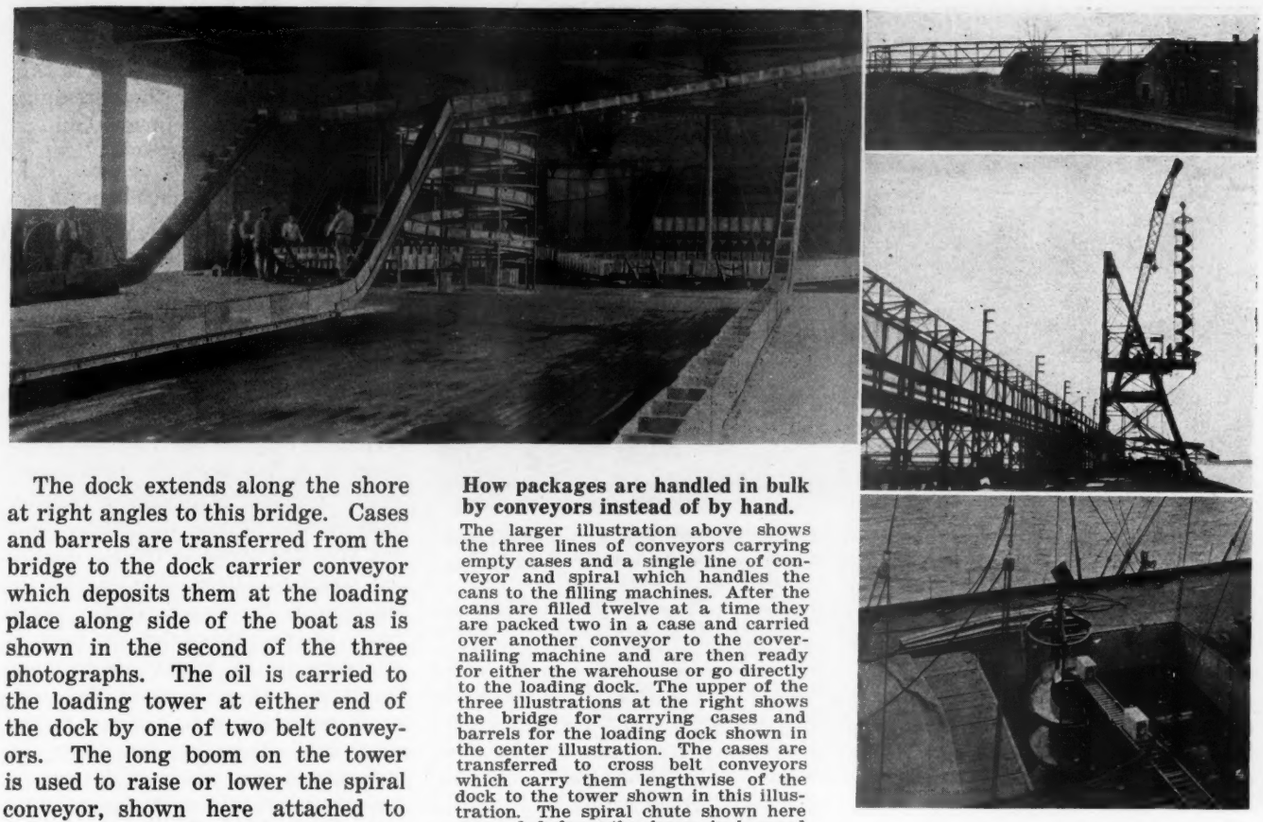
IN PLACES where material of a standard size is handled over any distance in large quantities at fairly regular intervals, it has often been found expedient to install permanent conveying equipment to do the work instead of using hand labor or truckers. Such at least was the experience of the Petroleum Import and Export Corporation of Louisiana, at its new plant on the Mississippi River, about 19 miles above New Orleans. The particular problems involved in this installation, in addition to those found in an ordinary industrial application of conveyors, were that the plant must be some distance from the wharf where the boats are loaded and that the loading is an intermittent but high-speed operation.

Here the petroleum products are exported in cans, two in a case. Three lines of gravity and chute conveyors carry the empty cases from the case-making department to the filling floor; another line of conveyors together with a spiral chute handles the cans to the filling machine, as is shown in the larger of the four illustrations accompanying this item. Cans are filled twelve at a time and packed two in a case, which is carried by a conveyor to the cover-nailing machine. They are then ready to be carried to the boat or to the warehouse until a boat is ready.

Because the docks must be placed in deep water it is necessary to carry the cases about 600 ft. from the warehouse to the dock, and along the dock to where the boat is standing. To do this, a double bridge conveyor, shown in the upper of the three small illustrations accompanying this item, was designed. The conveyors are arranged in two tiers. The upper tier consists for the most part of gravity roller conveyors wide enough to take two rows of oil cases. The lower tier consists of a run-way to carry barreled oil. The cases and barrels are filled on the ground floor and are raised to the proper conveyor by an inclined elevator and a barrel hoist.

A simple, permanent elevator installation which overcomes a slight difference between two floor levels.

In cases such as this, portable elevators or tiering machines placed in pits afford a simple and economical method of raising and lowering truck loads between the two levels. This installation is not only power driven, but the operator can control its movement, through a rope while he is in a working position on the platform.

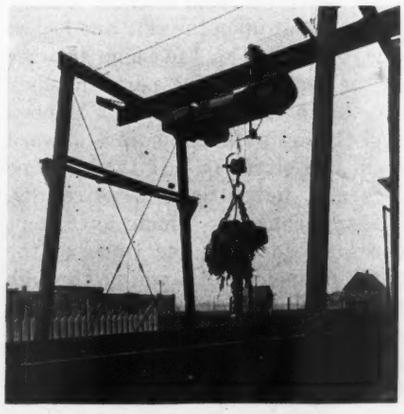


How packages are handled in bulk by conveyors instead of by hand.

The larger illustration above shows the three lines of conveyors carrying empty cases and a single line of conveyor and spiral which handles the cans to the filling machines. After the cans are filled twelve at a time they are packed two in a case and carried over another conveyor to the cover-nailing machine and are then ready for either the warehouse or go directly to the loading dock. The upper of the three illustrations at the right shows the bridge for carrying cases and barrels for the loading dock shown in the center illustration. The cases are transferred to cross belt conveyors which carry them lengthwise of the dock to the tower shown in this illustration. The spiral chute shown here suspended from the boom is lowered into the hold of the boat and lowers the cases by gravity.

The dock extends along the shore at right angles to this bridge. Cases and barrels are transferred from the bridge to the dock carrier conveyor which deposits them at the loading place along side of the boat as is shown in the second of the three photographs. The oil is carried to the loading tower at either end of the dock by one of two belt conveyors. The long boom on the tower is used to raise or lower the spiral conveyor, shown here attached to the boom, into the hold of the vessel. In actual operation, the cases are carried to this screw or spiral conveyor which lowers them into the hold, as shown in the third of the three accompanying illustrations, where the cases are distributed and piled. The cases are lowered to this spiral from the dock conveyor by gravity at low water; at high water a special booster elevates the cases to the top of the spiral to be lowered by gravity.

The savings which have been made by this installation are quite interesting. It would require a gang of fifteen stevedores to transfer from the dock to the ship 8,000 cases per day of 8 hrs. At present only one loading tower has been erected and one stream of cases is carried by the conveyor, which loads 1,800 cases per hr. or a total of 28,000 cases in an 8-hr. day, over three times the capacity of a 15-man gang. In addition, the conveying system carries these cases for the 600 ft. from the warehouse to the dock and along the dock to the loading point. If this were done by men with trucks it would require a gang several times as large as is used in loading to handle even the 8,000 cases per day over this distance, and in addition would require a large number of hand trucks or other types of trucks which would have to be kept in repair. Also, as this loading is intermittent work, the gang of men would be idle a large portion of the time, a factor which is conducive to high wages and often labor troubles. The Lamson Company, Syracuse, N. Y., designed and installed the conveying equipment.

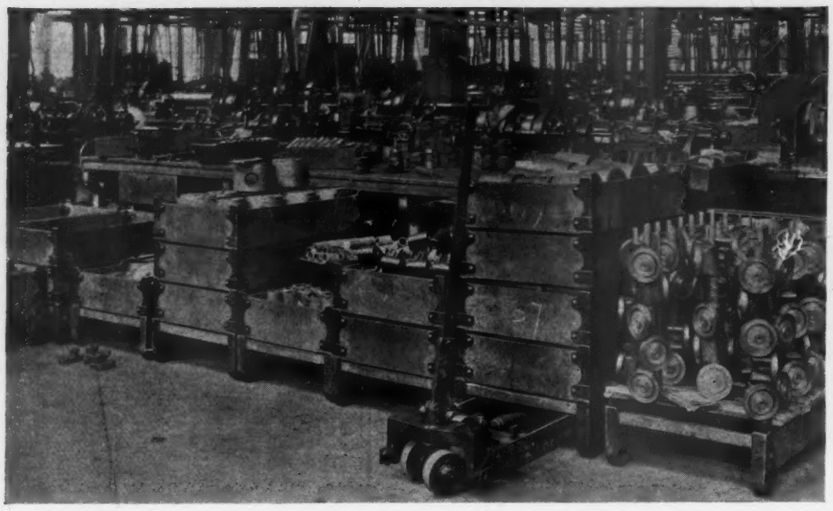


Three men with this hoist do in half a day the work which formerly took fifteen men all day.

Loading scrap into cars and handling 100 tons of steel plates a day do not occupy near all the time of this hoist. The 80-ft. runway allows the workers to distribute the steel over the storage yard. Wherever any considerable amount of metal is handled, it is well to investigate the adaptability of a magnet to do the work. The magnet and hoist do the kind of work that it is most difficult to get men to do in times of shortage of labor.

Magnet and Hoist and Three Men Do the Work of Fifteen-Man Gang

ONE OF the most difficult features of handling irregular shaped material, such as scrap or plate stock, lies in the difficulty of getting hold so that it can be lifted. For this type of work the Federal Pressed Steel Company used a magnet suspended from an I-beam, as shown in the accompanying illustration. This Pawling & Harnischfeger (Milwaukee, Wis.) two-motor type, pulpit control, 3-ton hoist is provided with a Cutler-Hammer (Milwaukee, Wis.) 43-in., circular lifting magnet. A 10-hp. hoist motor lifts at a speed at 35 to 75 ft. per min. A 6-hp. trolley motor gives a travel speed of 200 to 250 ft. per min. over an 80-ft. runway. The hoist operates on a 15-in., 42-lb., standard-section I-beam. The runway of the hoist passes over a concrete-lined pit, with a storage capacity of several carloads into which all sheet-metal scrap produced in the blanking, drawing and trimming operations is dumped. The magnet loads the scrap from pit to car in a few hours where formerly it required twelve men with wheelbarrows at least half a day. Also, as the scrap is dropped instead of dumped, it packs more into the car



One method of building up skid platforms to handle machined parts.
Compartment skids built up in sections in the way shown make a flexible arrangement for handling machined parts as they can be used as a flat platform or a box truck.

and so obtains a better freight rate.

But loading scrap is an infrequent operation. The greater part of the work of this hoist and magnet is in handling about 100 tons of steel plate which is received in gondolas daily. Formerly, this required a gang of twelve to fifteen men to unload and place in yard storage. Now one man in the yard, another in the car, and the hoist operator will easily unload 100 tons in four or five hours, a saving of the labor of ten or more men daily. In addition to unloading the hoist also can be used to pick up from storage steel required in the shop.

How Special Skids Protect Delicate Machined Parts During Handling

AN IMPORTANT feature in all lift-truck installations for handling material in industrial work is the designing and use of the proper type of skids for the particular work involved in that plant. Each plant has its own problems and many have such a variety of problems that it is necessary to design several different types of special skids to handle all the work. The type of skid evolved for use in the plant of the R. K. LeBlond Machine Tool Company, Cincinnati, Ohio, is shown in the accompanying illustration. This skid consists of a platform and a number of sectional boxes which can be set up on this platform. The castings locking the corners are so placed that as these sections are fitted together they are locked to prevent their slipping off. In one case shown, this is built up four tiers high and, if necessary, could be built higher.

If desired, each of these sections may have a bottom in it so as to make a tray if the parts are so delicate that they should not be piled on each other. With extremely delicate parts which would be damaged by coming in contact with each other if piled in loose, it is sometimes necessary to make small compartments or sections or use some other device for dividing off the tray so that the parts are separated from each other. The method used for holding parts with a hole in them, such as gears and other cylindrical pieces, is shown in the stake attachment for the skid at the right. Here a flat platform with upright pins or stakes is set upon the skid and locked at the corners in the same manner as the sections. The parts, as they are machined, are simply slipped over these pins extending upward from the platform. If this is done carefully, but little damage results.

Many concerns which have kept careful records of the value of the parts damaged in handling through being piled loosely and bumping against each other, have found that special skids or trays for holding these parts separate from each other will pay their entire cost many times over in a short time. This is particularly true in cases where parts are ground to close dimensions or have finely finished surfaces or sharp corners which could be nicked or scratched, which in either case would result in damaging the parts so that they would be worth only their scrap value. The value of the metal in most cases is very low in contrast to the labor which is expended upon it. The lift truck installation in this case was made by the Steubing Truck Company, Cincinnati, Ohio.

How Two Electric Trucks Supplanted a 40-Man Gang

INCIDENTALLY with the adoption of better material-handling equipment in industrial plants the method of doing the work is also changed, which often results in additional and frequently unanticipated savings. For example, in one steel foundry it had been the practice to place the green cores on steel-framed, four-wheeled trucks and push them into the core ovens to remain during the baking. Often, due to the intense heat, the truck wheels would "set" on the hot axles so that it would be almost impossible to move the truck. In such cases the core-truck would have to remain in the oven until it cooled enough to be moved, and thus hold up the use of the cores as well as of the oven.

When electric elevating-platform trucks were installed at this work, heavy core racks were built which could easily withstand the high heat of the baking ovens without sagging out of shape. One of these racks loaded with cores for baking weighs about 3 tons and is picked up on the elevating platform of the electric truck, carried to and deposited in the oven. As it requires only a moment, the elevating-platform truck can either deposit a loaded rack of green cores or pick up the baked ones, even though the oven is still hot. This makes a considerable saving, as it is not necessary to wait until the oven is cool enough for men to do this work. Thus there are more baking periods because the time between bakings is reduced.

When removed from the ovens, the cores are taken to the foundry, a distance of several hundred feet. Before these trucks were installed, a gang of more than forty men was required to truck the cores, but now two electric elevating-platform trucks, with one operator for each, handle the racks much faster, and as there are no hold-ups in getting the cores out of the oven, a continuous production is assured. The saving of the wages of forty men would alone pay for the cost of the new equipment within a few days.

Gears and Speed Reducers

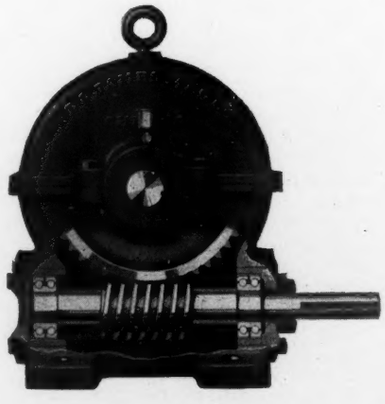
(*Continued from page 136*)

horsepower sizes to very large units capable of transmitting several thousand horsepower, at almost any desired speed ratio, and designed for practically every class and condition of service. In addition to eliminating more or less completely the necessity for belting, shafting and open gearing, with consequent saving in space, the use of these speed transformers relieves the bearings on the motor or other prime mover of a good deal of pressure and wear, inasmuch as they are direct connected and therefore exert no side pull.

There are two general types of speed transformer. In one type use is made of a worm and worm gear; in the other type, spurs, or herringbone gears are employed. In either case the gears are enclosed in a tight, dust-proof housing which is partially filled with oil, so that all working parts are well lubricated, although the gears do not in all cases run in a bath of oil.

Spur gear speed transformers are usually of the planetary type, wherein the revolving pinions are mounted on plates supported on the high-speed shaft. At least one company is, however, marketing a non-planetary type of transformer in which the idler pinions are supported independently of the central shaft.

The installation and operation of speed transformers is about the same as for any piece of machinery.



Cut-a-way view of worm gear speed transformer.

The worm shaft usually runs at high speed and is mounted on radial ball bearings with thrust bearings to take the end thrust. According to the service the worm wheel shaft is mounted on plain, roller or ball bearings.

They are frequently mounted on the same base as the motor, to which they are connected usually by a flexible coupling. If they are not mounted on the same base as the motor, a solid foundation, preferably concrete, should be provided and the motor and transformer shafts carefully aligned. Whenever a gear, pinion, pulley or sprocket is mounted on the high or low-speed shaft an outboard bearing should be provided, to take the weight and side pull.

The only attention required by these speed transformers is to see that they are supplied with sufficient lubricant of the character recommended by the manufacturer. Oil gauges are usually provided to show the level of the oil in the reservoirs.

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Commutator and Brush Troubles

(*Continued from page 155*)

7. *Use of Lubricant on Commutator.*—When lubricant is used on a commutator it is usually applied to reduce either sparking or noise or both, but it is sometimes applied more from habit than from necessity. If the brushes are noisy there will usually be sparking due to the brushes jumping from the commutator and the application of lubricant will afford temporary relief. The same troubles can be permanently eliminated by a change in brush pressure, angle of brush operation (see paragraph 10, page 582, of the article by the writer in the December issue) or a change in the grade of brush. If sparking is present without noise, the application of lubricant may afford temporary relief by producing a comparatively high resistance film on the brush faces. Permanent relief should be sought by using brushes with a higher contact drop, the correct spacing of the brushes, shifting of the brush yoke, or trimming down the brush faces to span fewer bars.

The continued and frequent use of lubricant will cause commutator heating and a black commutator due to poor contact between the brushes and commutator.

If the brushes have any abrasive action or if sandpaper or commutator stones are used where the commutator has been lubricated, the oil or wax that has soaked into the brush will tend to collect the copper particles on the brush faces and cause a low contact drop and poor commutation.

8. *Dirty Commutator.*—By dirty commutator is meant one on which external dirt is allowed to collect rather than one which appears black or dirty due to sparking or the use of the wrong brushes. A dirty commutator will cause heating due to poor contact between the brushes and the commutator.

It will pay to wipe the commutator frequently with a clean dry rag or waste. If the dirt is too greasy to be removed with a dry rag it will be best to use two rags, a small one soaked in gasoline with a larger dry rag held just back of it to collect the dirt as rapidly as it is loosened and thereby prevent the dissolved grease from collecting on the brushes.

9. *Difference in Hardness of Bars.*—This trouble is hardly ever encountered on new machines because all the bars are made at the same time. But after a commutator has been rebuilt, the new bars are sometimes softer or harder than the old bars. If they are softer, flat spots are likely to develop and if they are harder the trouble will be high bars, which in turn will cause flat spots.

About the only satisfactory remedy is the use of a commutator stone as soon as either trouble appears. The sooner the remedy is applied the less work it will require to remedy it.

10. *Difference in Hardness of Mica.*—There is a great deal of variation in the hardness of different grades of mica. When a commu-

tator is rebuilt the old mica left in part of the commutator and the new mica used between some of the bars may be different in hardness and the difference may be sufficient to cause uneven wear and result in flat spots. The best remedy for such trouble is to undercut the mica thereby eliminating its effect entirely.

11. *Commutator Not Properly Finished After Turning.*—After a commutator is turned, care should be taken to remove all burrs and tool marks with very fine sandpaper or a commutator stone. Improper finishing will cause commutator heating and rapid brush wear due to the rough copper surface.

12. *Commutator Too Small.*—This trouble is not often encountered in machines built by the manufacturer, but may be found when machines are rebuilt to operate at a lower voltage than that for which they were originally designed. The increased current may cause too much heating for the amount of radiation surface. The design of the machine may permit the installation of a larger commutator, but if not, it will be necessary to reduce the load or cool the commutator with a forced draft either by the installation of small fan blades on some part of the armature or commutator or by placing a fan to blow air on the commutator.

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of the bulletin or catalog desired, as given in these columns.

W. A. Jones Foundry and Machine Company, 4401 West Roosevelt Road, Chicago, Ill.—A new edition of the Jones spur gear speed reducer catalog, No. 26, is now ready for distribution to superintendents, chief engineers, master mechanics or to anyone who specifies mechanical drives for factories, if they will request copies on business stationary and give their name and title. This catalog contains a large amount of technical and practical information, complete descriptive matter, and illustrations of typical drives, as well as dimensions, weight and horsepower rating for complete speed reduction sets.

Republic Flow Meters Company, 2200 Diversey Parkway, Chicago, Ill.—Bulletin S-12 on "Measurement of Steam" describes the use of Republic Flow Meters in the measurement of steam distributed to different departments.

The Esterline-Angus Company, 227 East South Street, Indianapolis, Ind.—Bulletin 1122, entitled "How to Make a Plant Survey," describes the purpose, method and the results obtained by the systematic use of graphic instruments in industrial plants. Some of the topics discussed are: What instruments to purchase; voltage and power factor; analyzing power cost; use of power; maintenance and the monthly power bill.

The Sherwin-Williams Company, Cleveland, Ohio—A 40-page booklet on Sherwin-Williams "Ajax" insulating varnishes and compounds discusses the fundamental characteristics of insulating varnishes and describes the various types of baking and air-drying insulating varnishes, acid-proof paints, cable varnishes, wire enamel and insulating compounds. Several pages are devoted to general directions for the use of these varnishes and some of the common troubles experienced in their use, as well as methods of testing insulating varnishes.

Zeller Lacquer Manufacturing Company, Inc., 342 Madison Avenue, New York City—A 30-page booklet entitled "250 Lacquer Questions Answered," discusses by the question-and-answer method the problems connected with lacquering. This will be distributed to those interested requesting same on the letterhead of their company and giving their official position.

Maroa Manufacturing Company, Maroa, Ill.—The Maroa portable belt conveyor is described and illustrated in a bulletin which also contains numerous suggestions as to possible uses for this equipment.

Henry Heil Chemical Company, 212 South Fourth Street, St. Louis, Mo.—A small folder announces an improved Bunsen burner which, it is claimed, burns like a blow torch without the use of compressed air. This may be used for soldering, welding, annealing metals, heating insulating compounds and other industrial purposes.

The Cleveland Armature Works Company, 4732 St. Clair Avenue, Cleveland, Ohio—Bulletin 303 describes the line of C. A. W. electric medium-duty grinders with direct motor drive. A sectional drawing shows the construction and various types of mountings—pedestal, bench and post types. A special shaft lock holds the shaft when changing wheels on the 2-hp., 1,800-r.p.m. and larger sizes and enables one man to change wheels. Bulletin 408 describes the line of electric buffers and polishers for the plating and metal-finishing room.

The Okonite Company, Passaic, N. J.—Recent literature announces "Okocord," a flexible cord designed for use in rough, wet or oily places in factories, shops or wherever it is necessary for the moment to carry power or light.

Frank Adam Electric Company, St. Louis, Mo.—Bulletin 26 describes the new Triumph panelboard type T-P (with tumbler switch and plug fuses). A particular feature of this is the unit construction. Numerous diagrams of various types of safety panelboards and cabinets are included.

The Black and Decker Manufacturing Company, Towson Heights, Baltimore, Md.—Catalog 5, entitled "Portable Electric Tools and Shop Equipment," describes in detail the construction of the Black & Decker electric drills, their construction and operation as well as including the prices of the various types of equipment. The section devoted to "How to Grind Drill Bits" describes the grinding and methods of testing the accuracy of sharpened drills so that they will give the best service in use. Other Black & Decker appliances described are bench and portable types of electric grinders and air compressors.

The O. C. White Company, Worcester, Mass.—Catalog entitled "White Adjustable Electric Light Fixtures for Applied Illumination" devotes 16 pages to the description of the various types of "White" portable lamps and lamp standards, ceiling fixtures, wall fixtures and portable lamp stands of various kinds.

E. C. Atkins and Company, Indianapolis, Ind.—A booklet entitled "Atkins Saws in the Shops" describes the various types of Atkins metal-cutting saws from hack saws to circular and friction saws, as well as band saws. A chart gives the proper speed, catalog number and description of different hack saws to be used to cut any of over thirty different materials. Another booklet describes the Atkins "Kwik-Kut" metal-cutting machine for both motor and belt drive. One of the special features of this machine is that it is claimed to automatically adjust the length of the stroke and use practically the entire blade at each stroke, with a corresponding saving of hack saw blades. Descriptions of the mechanical and electrical features are included as well as prices on the different sizes.

The Electric Controller and Manufacturing Company, Cleveland, Ohio—A folder describes construction and gives the advantages claimed as well as a phantom view of the type NC squirrel-cage 40-degree induction motors recently announced.

The Alexander Milburn Company, 1416 West Baltimore Street, Baltimore, Md.—A 24-page booklet describes the Milburn welding and cutting apparatus, which includes acetylene generators of stationary and portable types and welding and cutting torches.

McGill Manufacturing Company, Valparaiso, Ind.—A vest-pocket folder entitled "The Efficient Guard" describes and illustrates the several types of "Loxon" lamp guards.